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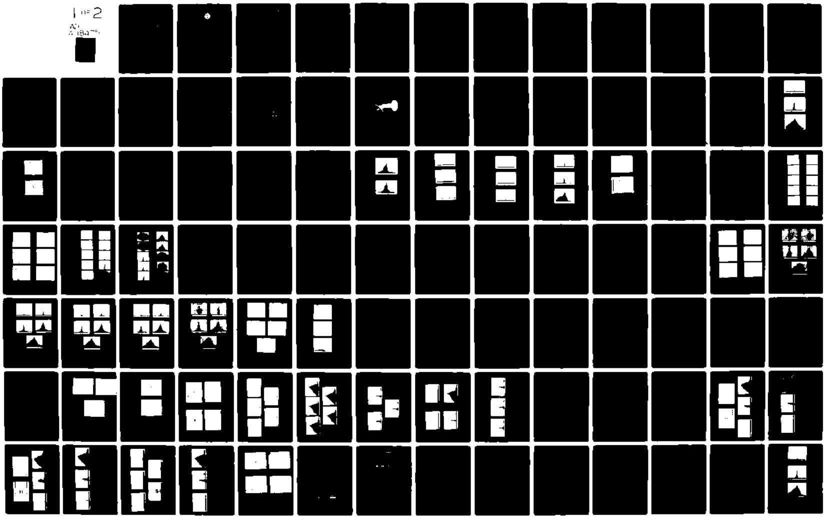

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Contractor Report 112

CONSTRUCTION, TEST AND DELIVERY OF STANDARDIZED COAXIAL MAGNETRON - FINAL REPORT

T. E. Ruden
Varian Associates, Inc

23 September 1981

Prepared for
Naval Ocean Systems Center

AD A118475

Approved for public release; distribution unlimited

NOSC

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

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HL BLOOD
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A VMS-1104 coaxial magnetron was constructed and evaluated. The SPN-43 radar transmitter cabinet was modified to accept this tube; satisfactory operation of the tube and modification kit in an SPN-43 system was demonstrated at a Navy test facility.

An additional VMS-1104 tube and spare vacuum insert was constructed, tested and delivered. Spurious signal generation from these tubes is -50 dB or better. A VMS-1054 coaxial magnetron was constructed and evaluated. Satisfactory rf performance was demonstrated. Spurious signal generation from this tube closely approximated -60 dB.

-FINAL REPORT-

CONSTRUCTION, TEST AND DELIVERY OF STANDARDIZED COAXIAL MAGNETRON

PERIOD COVERED: JULY 16, 1979 - APRIL 17, 1981

PREPARED FOR:

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Photograph of VMS-1054, Band I, Standardized Coaxial Magnetron

Test Specification, VMS-1104

Test Specification, VMS1054

Standardized Magnetron Vacuum Insert (SK-33941)

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1.0 INTRODUCTION

Under contract No. N00039-76-C-0036, a family of four standardized, one megawatt, S-band, coaxial magnetrons was developed. Each of these magnetrons covered a portion of the frequency range of 2.7-3.7 GHz. Two of the tubes, VMS-1104 and VMS-1054, were selected to be further developed to improve various electrical and mechanical performance characteristics. This work was performed under contract N00039-79-C-0150. Under the present program, work was under taken to construct, test and deliver to the Air Force and Navy models of these improved tubes. In addition, a modification kit to the SPN-43 radar transmitter cabinet was constructed to insure compatibility of the coaxial magnetron, system modulator and waveguide system. Installation and demonstration of performance of the coaxial magnetron and modification kit in a Navy SPN-43 system was accomplished.

The following sections of this report include:

Section 2.0	Summary of Program Requirements
Section 3.0	Description of the SPN-43 Modification Kit
Section 4.0	Performance of the VMS-1104 Coaxial Magnetron and Evaluation of Operation in the SPN-43 Radar System
Section 5.0	Performance of the VMS-1054 Coaxial Magnetron
Section 6.0	Conclusions

2.0 SUMMARY OF PROGRAM REQUIREMENTS

For reference purposes, the following "Description or Specifications" pertaining to this contract are included below.

Contract No. N66001-79-C-0225

SECTION F--Description or Specifications

Statement of Work

Proposed Program for Construction, Test and
Delivery of Standardized Coaxial Magnetron

F.1 Introduction

This statement of work requires the contractor to construct, test and deliver a family of one megawatt, standardized coaxial magnetrons that operate in the following frequency bands:

Band I	2.7 - 2.9 GHz
Band III	3.1 - 3.5 GHz
Band IV	3.5 - 3.7 GHz

Each magnetron of the family consists of two sections: a tunable cavity and a separable vacuum insert containing the RF interaction structure, the cathode, and the required magnets. Under a prior Navy contract, N00039-76-C-0036, this family of standardized coaxial magnetrons was developed. The program demonstrated that a family of one megawatt tubes, one for each band, operating at the same anode voltage and current and using the same filament voltage could be developed. Now that the concept has been demonstrated,

it is necessary to evaluate the tubes and characterize their performance. This effort provides for the construction and evaluation of tubes and the development of tube specifications in MIL-E-1 format. Since the form and performance characteristics differ from tubes used currently in military radar systems, it is necessary to develop a modification kit for electrical and mechanical mating of the magnetrons to the transmitter.

F.2 Scope

This effort provides for the fabrication of one Band I, one Band III, and two Band IV tubes with one additional insert. The effort also provides for characterization of each device, life testing of one Band IV tube, and delivery of one Band IV tube to a Navy site for compatibility testing. In addition, the effort requires the development of a modification kit to electrically and mechanically mate the Band IV tube to a transmitter.

F.3 Applicable Documents

MIL-R-978 Reports

DOD-D-1000B Drawings, Engineering and Associated Lits

MIL-E-1 Electron Tubes, General

F.4 Requirements

The contractor shall fabricate standardized coaxial magnetrons for Bands I, III and IV. Each magnetron shall develop a minimum of one megawatt of peak output power. The specific tasks are the following:

a. One (1) tube in each band (Band I, Band III and Band IV) shall be fabricated and tested. Delivery shall be made to the Navy after testing in Varian test equipment and witnessing by USN personnel as designated by NOSC. The Band IV tube suitable for use in the SPN-43A shall be delivered to a designated USN test site with an appropriate installation and modification kit to allow field test.

b. A second Band IV tube will be fabricated, tested and delivered to the Navy. This tube will then undergo life test evaluation in Varian equipment or SPN-43A equipment available at Varian/Beverly. The test shall have an objective duration of 2,000 hours (1,000 hours minimum) during the contract.

c. One additional vacuum insert of the Band IV design will be fabricated, tested and delivered.

d. For each band, a tube specification in MIL-E-1 format shall be prepared.

e. A modification kit to mate the Band IV tube to the SPN-43A shall be completed.

F.5 Delivery

a. Hardware Items

(1) Coaxial magnetron, Band I, one (1) tube (cavity and insert--1 each).

(2) Coaxial magnetron, Band III, one (1) tube (cavity and insert--1 each).

(3) Coaxial magnetron, Band IV, two (2) tubes (cavity and insert--2 each).

(4) Band IV insert (1 each).

(5) SPN-43A modification kit (1 each).

The cavity and insert items will be delivered in accordance with the following frequency designation and tube type:

Band I	2.7 - 2.9 GHz	VMS-1054
Band III	3.1 - 3.5 GHz	VMS-1089
Band IV	3.5 - 3.7 GHz	VMS-1104

b. Specifications in MIL-E-1 format covering tubes in each band shall be delivered.

c. Drawings per DOD-D-1000B, Level 1, and specifications per MIL-E-1 shall be delivered concurrent with delivery of the final report. Drawings shall consist of cross-sectional layout showing outline of the cavity, outline of the insert and modification kit details.

d. A milestone plan, quarterly reports and final report per MIL-R-978 shall be delivered in accordance with DD Form 1423.

Modifications to the above requirements and delivery of items made during the program are: deletion of Band III fabrication, test, and delivery, and deletion of life test of second Band IV tube.

3.0 DESCRIPTION OF SPN-43 MOD KIT COMPONENTS

This section of the report indicates the major components of the modification kit developed for the SPN-43 transmitter cabinet. Reference is made to the document "Engineering Drawings", Volume II, SPN-43A Modification Kit, 23 January 1981, which provides the details of each component.

3.1 Hotbox (SK-33982) - High Voltage Component Cabinet

The hotbox design followed closely that employed in the original SPN-43. The redesigned hotbox employs those original components as heater bypass capacitor, chokes and spark gap, plus added components for voltage rate-of-rise adjustment consisting of a capacitor C and resistor R.

Figure 3.1 shows the modulator circuit diagram with added components, and Figure 3.2 shows the physical layout of the components in the hotbox. The section of the hotbox containing the spark gap, etc. is identical to that employed in the present system, but is rotated through an angle of 90 degrees when mounted on the rear wall of the transmitter cabinet.

3.2 Filament Transformer (SK-33989)

A filament transformer (T), Figure 3.1, has been added to provide a standby heater voltage of 66 volts.

3.3 Pulse Transformer

A wiring change on the input to the pulse transformer, Figure 3.1, was made. Lead to Pin 3 was removed, and this lead connected to Pin 2.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	UPDATED PER TR# 81-6173	5/12/81	HW

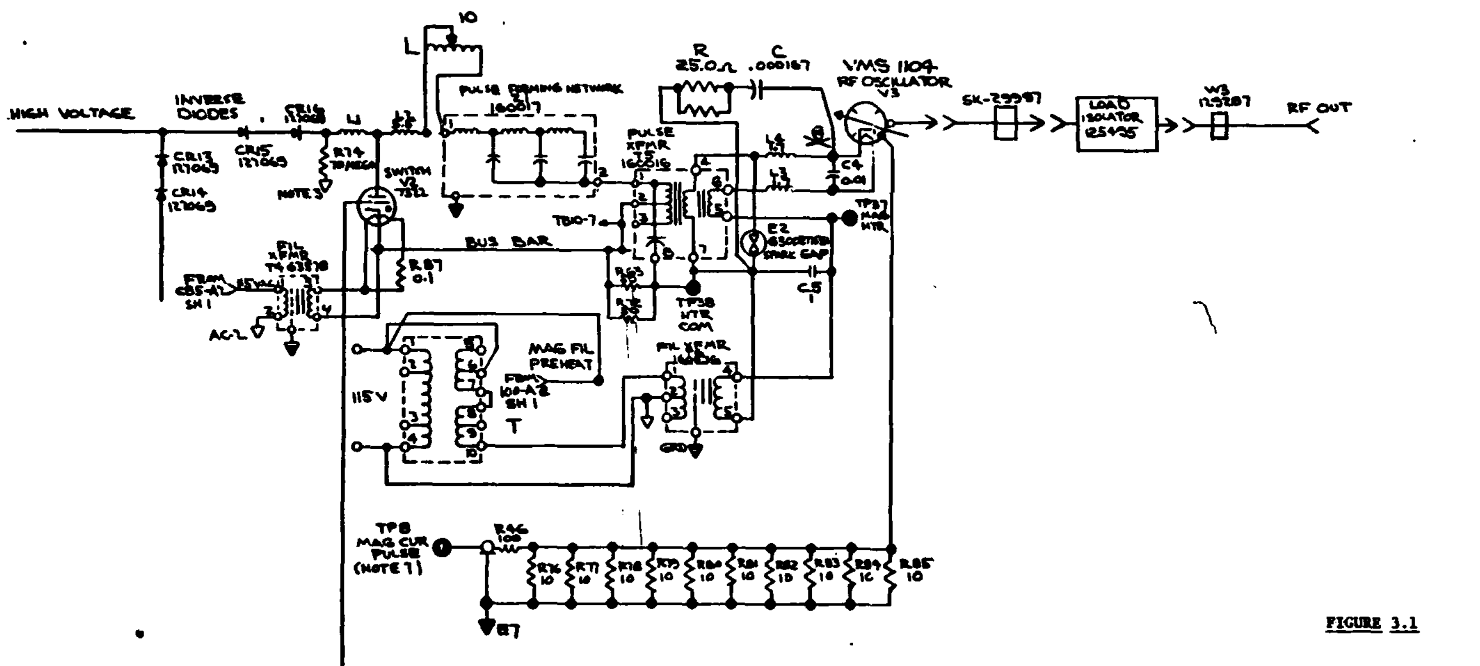


FIGURE 3.1

QTY	DESCRIPTION	IDENTIFYING NO	SPECIFICATION	MATERIAL	ITEM NO

LIST OF MATERIALS

VARIAN/BEVERLY FABRICATION STANDARDS 302368 APPLIES TO THIS DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON	CONTRACT NO.
FRACTIONS ± 1/64 · DECIMAL .XX ± .01 · DECIMAL .XXX ± .005	DR R.P. BENOIT 4-22-77
ANGLES ± 0°30' · SURFACE QUALITY 63 V MAX	CHK
MATERIAL	APPD
	APPD
	DESIGN ACTIVITY

varian/beverly

MOD. DRAWING SPN 43 TO ACCEPT VMS 1104 MAGNETRON

SIZE	CODE IDENT NO.	
B	88236	SK-30628
SCALE		SHEET OF

NEXT ASSY	USED ON
	VMS 1104

APPLICATION

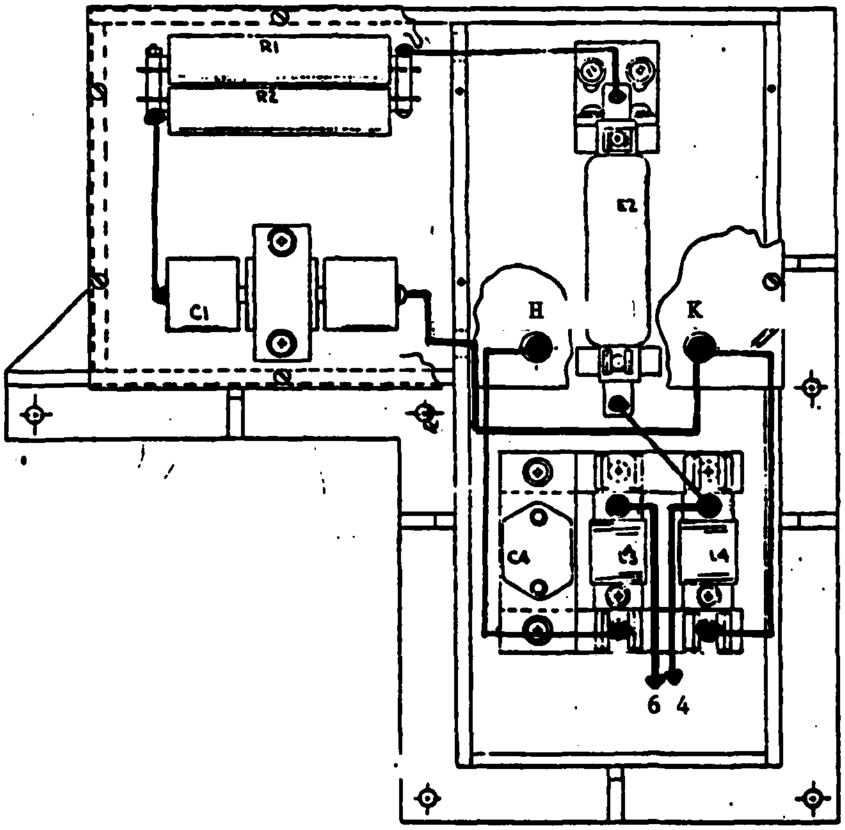


FIGURE 3.2

HOTBOX COMPONENTS

3.4 PFN Coil (SK-33953)

An inductor (L) has been added to the input of the PFN, Figure 3.1.

3.5 Waveguide Run

Detailed drawings of the waveguide run were made such that the output of the coaxial magnetron could be aligned with the SPN-43 system waveguide. The location of the system waveguide is established per ITT drawing No. 125446. In the final configuration, the coaxial magnetron was connected via flexible waveguide to the rf isolator in a manner similar to that employed to connect the conventional magnetron to the waveguide.

3.5.1 Flexible Waveguide (SK-33205)

A flexible waveguide section, Figure 3.3, having an H plane bend was designed. With the insertion of the coaxial magnetron into the SPN cabinet by approximately one inch, the combined E and H plane rigid guide bend previously designed was eliminated.

Figure 3.4 shows the details of the waveguide flange interface in the system. The flexible waveguide is attached to the tube flange as an insulated section via the use of an insulating gasket and insulating bushings about the waveguide mounting bolts. Provision has been made for introduction of ship air into the waveguide run.

The flexible guide was specified for a VSWR of 1.10 over the frequency range of 3.5-3.7 GHz. This VSWR is compatible with the specification for the flexible guide used in the original system.

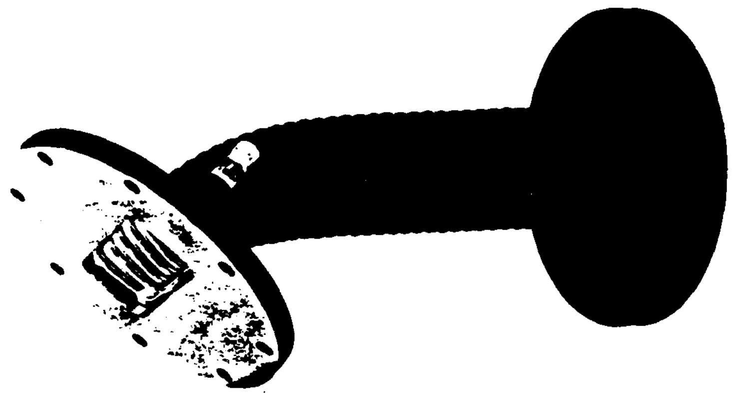


FIGURE 3.3

FLEXIBLE WAVEGUIDE SECTION

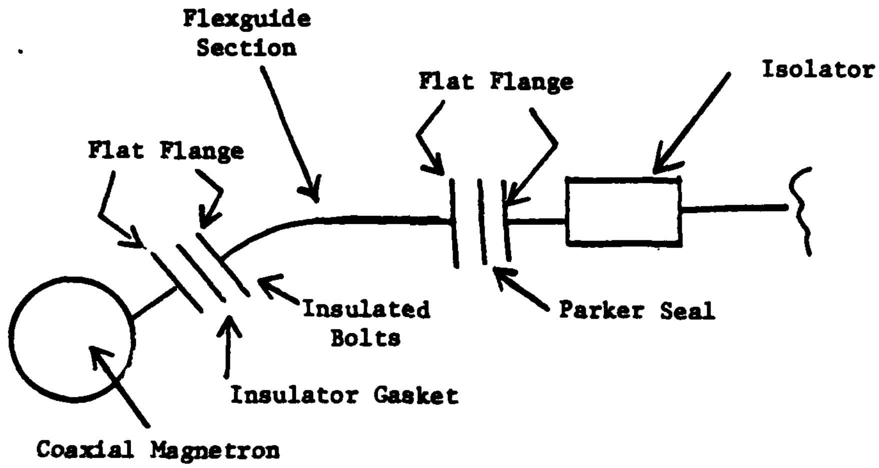


FIGURE 3.4

WAVEGUIDE FLANGE CONFIGURATION

3.6 Transmitter Door

The present relocation of the coaxial magnetron deeper into the transmitter cabinet allows the transmitter door to be located in its original position, thus eliminating the door spacer required in an earlier configuration. Relocation of the door interlock switch was required due to interference with the mounting saddle of the magnetron.

3.7 Ship Air Pressure Switch

The insertion of the magnetron deeper into the cabinet to obtain proper alignment of the tube and waveguide run required relocation of the ship air pressure switch. The switch was moved approximately two inches deeper into the cabinet and rebolted to the cabinet wall. A suitable RFI gasket was installed.

3.8 Cavity Saddle, Loading Yoke and Base Insulator (SK-33951)

The design of the support base or saddle, loading yoke, and insulator for the cavity is basically that designed during the previous program. The design of the support base was modified slightly to adapt to the greater insertion of the magnetron into the cabinet.

3.9 Magnetron Cooling

The relocation of the magnetron in the cabinet required redesign of the saddle air cooling channel leading from the cabinet blower to the cooling fins of the magnetron. Improved uniformity of air flow to the cooling fins was achieved.

An additional air line was connected from the cabinet blower to an air duct (SK-33948) to direct air on the input stem of the magnetron.

3.10 Cavity Pressurization and Pressure Switch

A hose configuration for the cavity and the pressure switch, and the main cavity feed line from the SF_6 gas tank to the cavity was established. Assistance of NESEA will be required in establishing suitable system specifications for these items.

4.0 PERFORMANCE OF BAND IV, VMS-1104 COAXIAL MAGNETRON

4.1 Initial Test of Band IV, VMS-1104, S/N 1005

4.1.1 Operation in SPN-43 Transmitter Cabinet

Table 4.1 provides VMS-1104 (S/N 1005 insert with "A" cavity) coaxial magnetron performance. Operation was in the SPN-43 transmitter cabinet with mod kit components installed. An S-band water load was used to measure the power output from the transmitter cabinet. Note in this configuration system isolator is in the waveguide run in the cabinet. Pulse width was 0.9 microsecond, duty cycle set at 0.00086 and data taken at the 44 ma average current level (maximum current level of the modulator). These data show very satisfactory performance operating into the SPN modulator. Note leading edge jitter data also presented for reference purposes only.

An additional set of data was taken at the 40 ma level and is presented in Table 4.2.

Figure 4.1 shows the spectrum of the tube at 40 ma average, 46.5 ampere peak level. Spurious is better than -50 dB below the 3700 MHz signal, side lobe ratio is some -10 dB, and spectrum width at -40 dB is less than 13 MHz. The detected rf pulse is shown in Figure 4.2. As observed at 0.05 microsecond/division horizontal display, the peak-to-peak time jitter is some 10 nanoseconds, which implies an rms value of 2 nanoseconds. The video data is thus in accord with the measured data of Table 4.2.

TABLE 4.1

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1005 and "A" CAVITY OPERATING IN SPN-43 TRANSMITTER CABINET

$I_{avg.}$ = 44 ma; tpc = 0.9 μs; duty = 0.00086; V_f = 0.0 Volts

Frequency (MHz)	Power (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Missing Pulses (%)	Pushing (KHz/amp)	Leading Edge Jitter (ns)
3500	849	1.2	-10.0	0.00	18	2.6
3525	919	1.2	-11.0	0.06	20	7.2
3550	907	1.3	-10.5	0.08	20	8.2
3575	930	1.3	-10.5	0.06	20	5.8
3600	930	1.2	-10.0	0.05	22	8.2
3650	924	1.3	-10.5	0.00	20	6.8
3700	849	1.2	-10.0	0.00	20	4.4

May 27, 1980

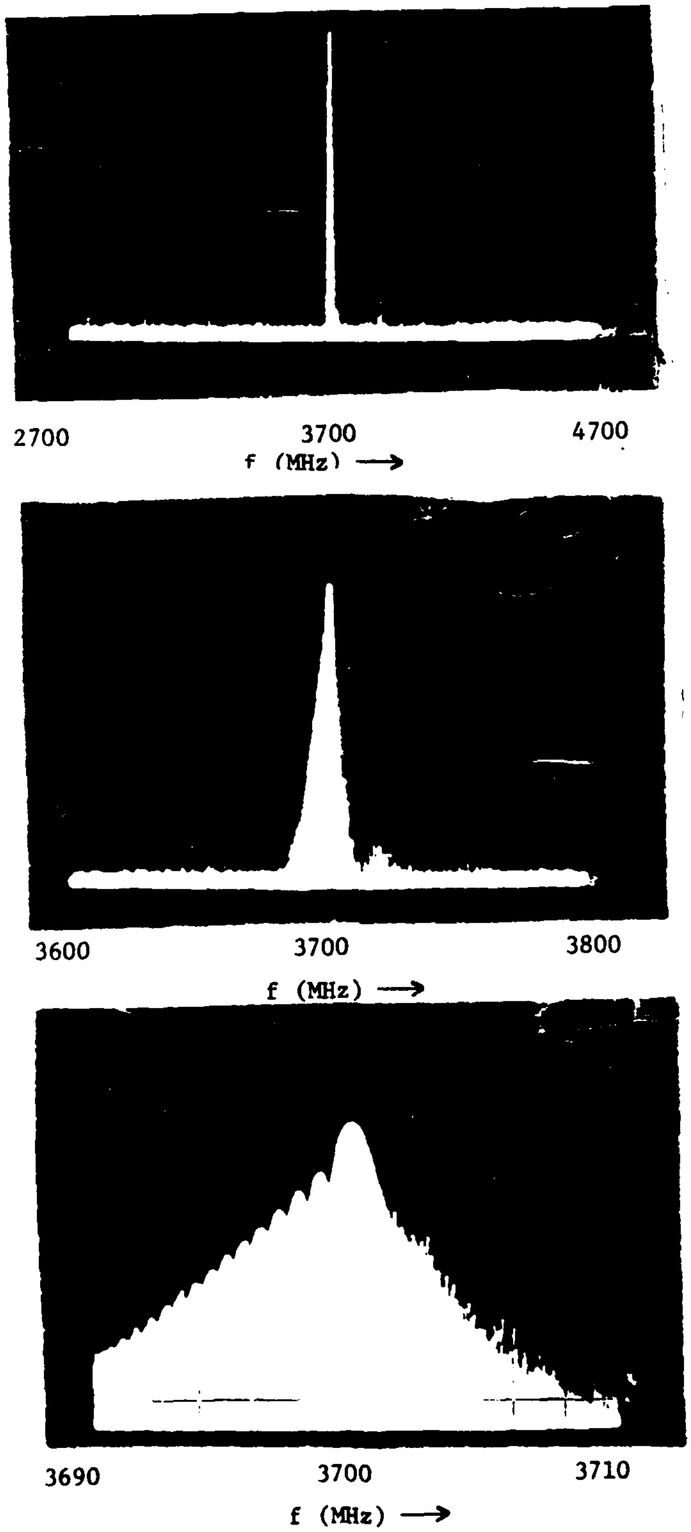
TABLE 4.2

TEST RESULTS, BAND IV COAXIAL MAGNETRON VMS-1104, S/N 1005 and "A" CAVITY OPERATING IN SPN-43 TRANSMITTER CABINET

$I_{avg.}$ = 40 ma; tpc = 0.9 μs; duty = 0.00086; V_f = 0.0 Volts

Frequency (MHz)	Power (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Missing Pulses (%)	Pushing (KHz/amp)	Leading Edge Jitter (ns)
3500	780	1.2	-10.0	0.00	20	1.0
3575	814	1.3	-10.0	0.02	22	5.4
3700	767	1.3	-10.0	0.00	22	1.5

May 27, 1980



Spurious - 54 dB

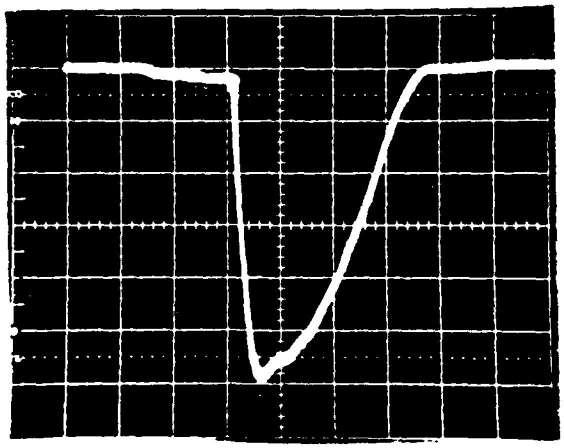
Spurious <-50 dB

Side Lobe at -10 dB
Bandwidth at -40 dB
13 MHz

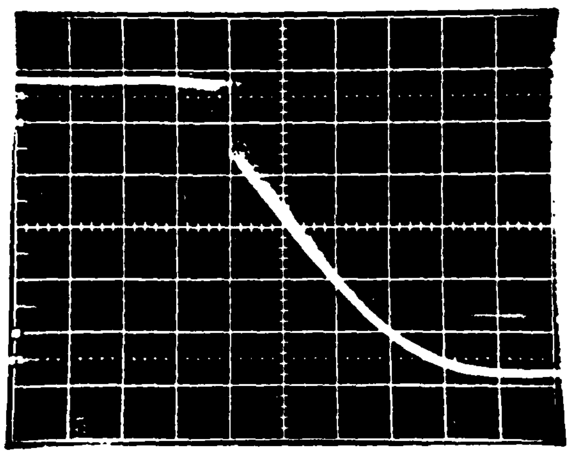
FIGURE 4.1

Spectrum, VMS-1104, S/N 1005, "A" Cavity, SPN Operation

I_b = 40 ma (average); Duty = 0.00086; f = 3700 MHz



a.) Horizontal = 0.5 microsecond/division



b.) Horizontal = 0.05 microsecond/division

FIGURE 4.2

Detected RF Pulse, VMS-1104, S/N 1005, "A" Cavity, SPN Operation

I_b = 40 ma (average); Duty = 0.00086; f = 3700 MHz

May 28, 1980

4.1.2 Full Power Test

The VMS-1104 insert S/N 1005 and "A" cavity were tested on the Varian/Beverly K-277 engineering modulator to evaluate performance at the one megawatt peak, one kilowatt average power level. The modulator provided a 1.9 microsecond pulse, and the duty cycle was adjusted to provide 0.001 value. Table 4.3 presents data taken at the 50 ma average, 50 ampere peak current level. Spurious is -50 dB or better across the tuning range of the tube as indicated in Table 4.4.

Figure 4.3 shows the spectrum at 3700 and 3550 MHz at 5 MHz/division horizontal display. At approximately 3550 MHz we observed on test some weak flyout instability on the rf detected pulse. This instability was not severe enough to be recorded as missing pulses in the previous measurements. We observed no major degradation in the spectrum at 3550 MHz as compared to 3700 MHz.

The spectrum width* at -40 dB is some 10 MHz. This value satisfies the present requirement of spectrum width = 20/tpc, but does not satisfy advanced system requirements of 10/tpc. Note this tube operating in the SPN equipment does satisfy the long range requirement. Work on the pulse forming network of the test modulator would be required to reshape the pulse on this test kit such that the spectrum width is consistent with 10/tpc spectrum width requirements.

The tube was operated at 60 ma with the data shown in Table 4.5 obtained. The corresponding spectrum photographs are

*Technical Manual, T.0.00-25-251, and MIL-E-1-4308.

shown in Figures 4.4 to 4.6. In Figure 4.6 the side lobe ratio is -13 dB, and the spectrum width at -40 dB is 10.5 MHz.

Figure 4.7 shows the detected rf pulse. The photo with expanded scale shows the leading edge jitter to be less than 10 nanoseconds peak-to-peak, thus some 2 nanoseconds rms.

TABLE 4.3

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1005, "A" CAVITY

Test Modulator: K-227; $I_{avg.}$ = 50 ma; tpc = 1.9 μs; duty = 0.001; V_f = 55 Volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Bandwidth (MHz) (1)	Bandwidth (MHz) (2)	Side Lobe Ratio (dB) (1)	Side Lobe Ratio (dB) (2)	Missing Pulses (%)	Pulling (MHz)	Pushing (KHz/amp)	Leading Edge Jitter (ns) (1)	Leading Edge Jitter (ns) (2)
3500	40.5	1040	0.60	0.63	-11.0	-10.5	0.03	1.2	11.0	4.3	4.8
3550	41.0	1050	0.60	0.65	-10.0	-10.0	0.04	1.5	11.0	5.0	5.5
3600	41.9	1090	0.65	0.80	-10.0	- 9.5	0.08	1.6	20.0	6.3	8.5
3650	41.9	1110	0.60	0.60	-11.0	-11.0	0.00	1.4	11.0	5.8	5.8
3700	42.0	1080	0.65	0.70	-10.0	- 9.5	0.00	1.4	10.0	4.0	4.9

(1) Matched Load

(2) 1.5:1 VSWR, Worst Phase

May 30, 1980

TABLE 4.4

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1005 "A" CAVITY

Test Modulator: K-277; $I_{avg.}$ = 50 ma; tpc = 2 μs; duty = 0.001; V_f = 55 Volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Spurious (dB)	Comments
3500	40.5	1040	-55	+400 MHz
3550	41.0	1040	-50 -55	+400 MHz, +200 MHz
3600	41.5	1040	-50	(+400, + 200 MHz)
3650	42.0	1050	-54	+300 MHz
3700	42.0	1020	-50 -60	+200 MHz +300 MHz
				TE_{121} Mode -55 to -60 dB at all frequencies.

May 29, 1980

TABLE 4.5

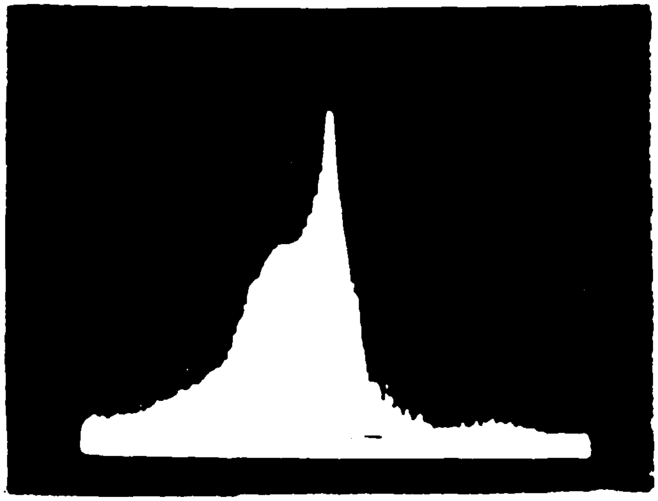
TEST RESULTS, BAND IV COAXIAL MAGNETRON VMS-1104, S/N 1005, "A" CAVITY

Test Modulator: K-277; $I_{avg.}$ = 60 ma; tpc = 2 μs; duty = 0.001;
V_f = 55 Volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Comments
3500	41.5	1125	-55 dB, +450 MHz (time dependent)
3550	--	1175	-50 dB
3600	--	1200	-50 dB
3650	--	1240	-50 dB
3700	42.0	1175	-50 dB +200 MHz

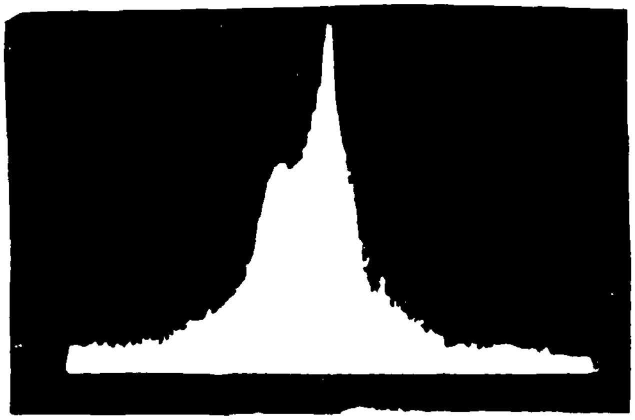
TE_{121} mode -55 to -60 dB at all frequencies.

May 29, 1980



f (MHz)

3676 3700 3725



f (MHz)

3525 3550 3575

FIGURE 4.3

Spectrum, VMS-1104, S/N 1005, "A" Cavity, K-277 Test Modulator

I = 50 ma (average); Duty = 0.001

May 29, 1980

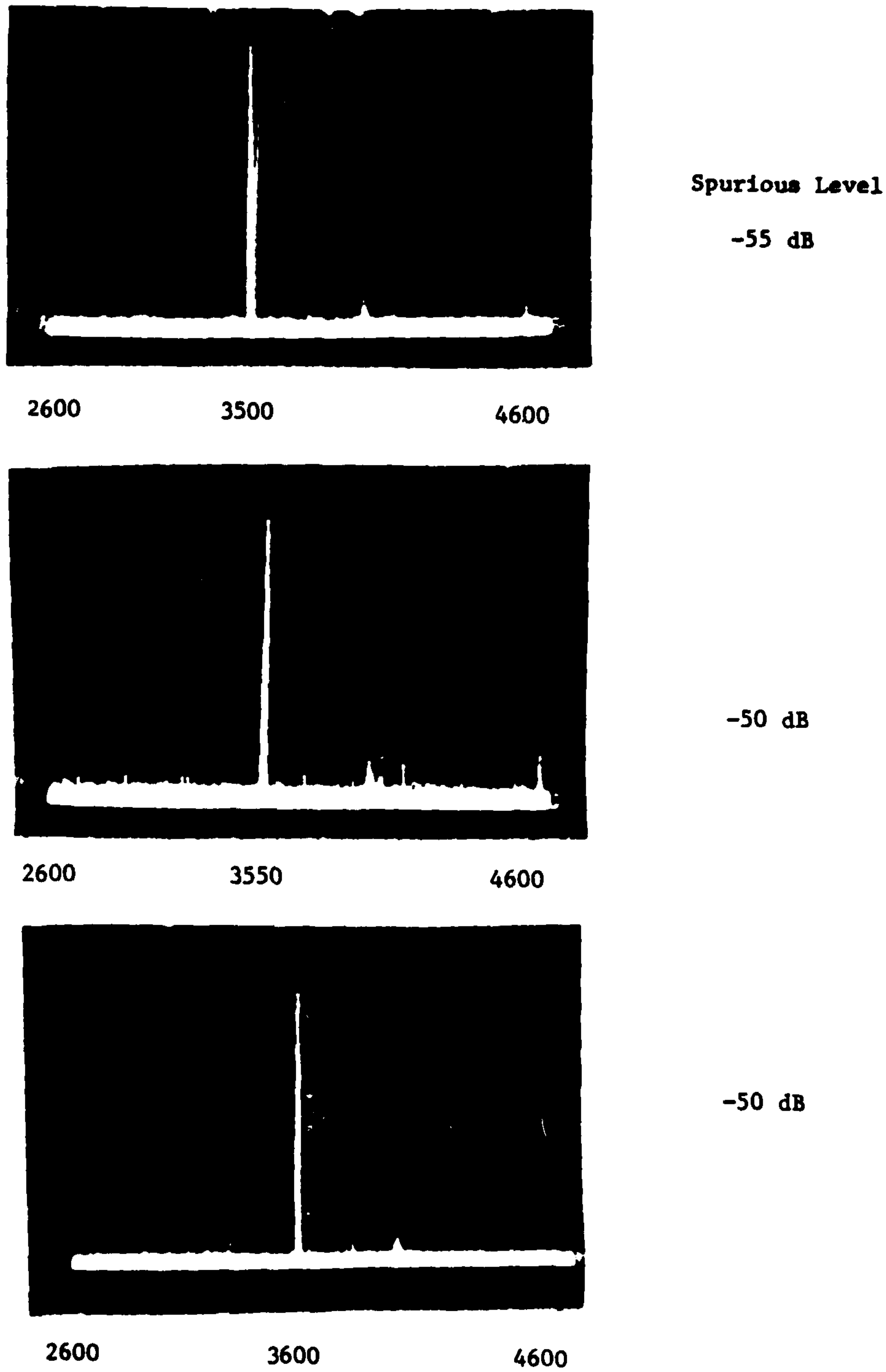


FIGURE 4.4

Spectrum, VMS-1104, S/N 1005, "A" Cavity, K-277 Test Modulator

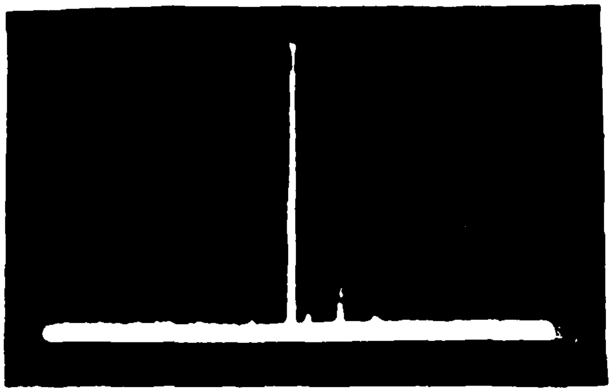
I = 60 ma (average); Duty = 0.001

May 29, 1980

Spurious Level

-50 dB

3650 MHz



-50 dB

3700 MHz

Horizontal 200 MHz/div.

-50 dB

3700 MHz

Horizontal 100 MHz/div.

FIGURE 4.5

Spectrum, VMS-1104, S/N 1005, "A" Cavity, K-277 Test Modulator

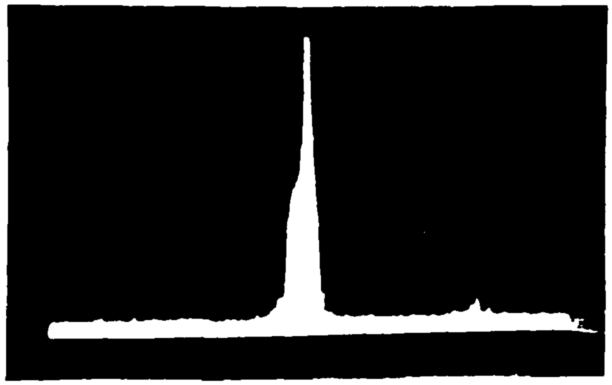
I = 60 ma (average); Duty = 0.001

May 29, 1980

Spectrum Level

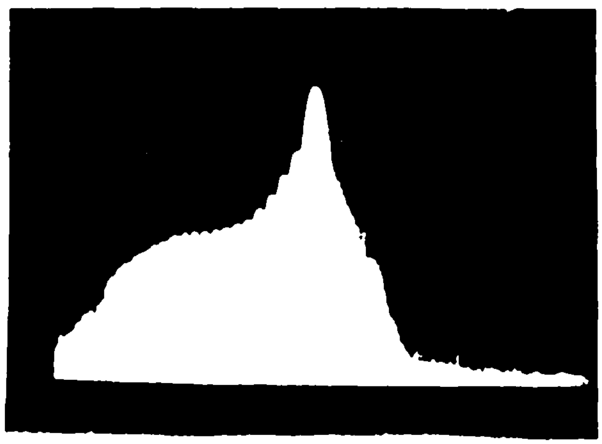
-50 dB

3700 MHz
Horizontal 50 MHz/div.



-58 dB

3700 MHz
Horizontal 20 MHz/div.



Spectrum Width
@ -40 dB = 10.5 MHz

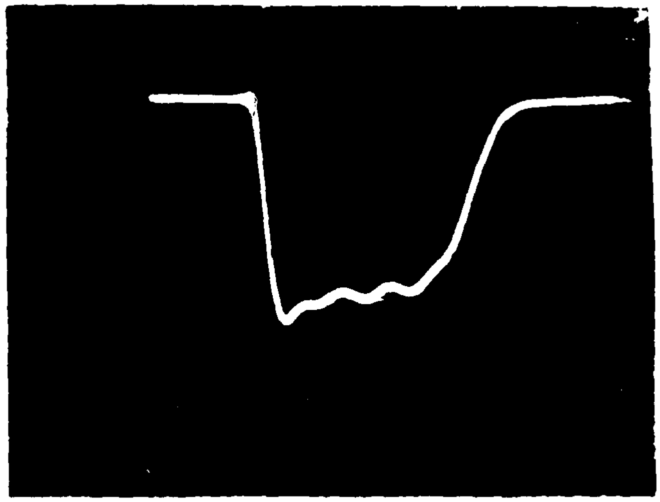
3700 MHz
Horizontal 2 MHz/div.

FIGURE 4.6

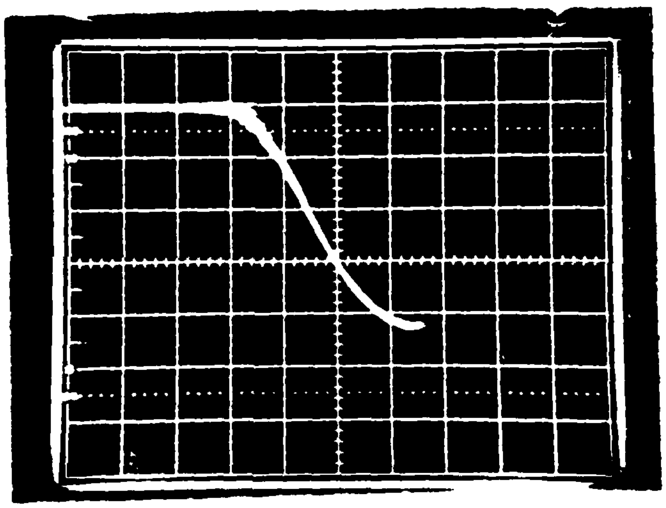
Spectrum, VMS-1104, S/N 1005, "A" Cavity, K-277 Test Modulator

I = 60 ma (average); Duty = 0.001

May 29, 1980



Horizontal 0.5 microsecond/div.



Horizontal 0.1 microsecond/div.
Frequency = 3700 MHz

FIGURE 4.7

Detected RF Pulse, Spectrum, VMS-1104, S/N 1005, "A" Cavity, K-277 Test Modulator

I = 60 ma (average); Duty = 0.001

May 29, 1980

4.2 Final Test of Band IV Tube, VMS-1104, S/N 1005

The Band IV "A" cavity was inspected and adjustments made in an attempt to correct the minor flyout instability observed in the tests described above. The tube was retested in the SPN-43 cabinet, and the data of Table 4.6 obtained. Excellent performance was obtained in the SPN equipment.

Figure 4.8 shows the detected rf pulse at a horizontal display of 0.5 microsecond/division and expanded to 0.05 microsecond/division. Note the leading edge of the rf pulse shows very low jitter in agreement with the measured data. Figure 4.9 shows the rf and voltage pulse.

In the previous tests the tube showed very minor tendency for a flyout type of instability in the frequency range of 3550-3575 MHz with low level spurious generation at +200 MHz. On early test of the tube after cavity adjustment, a search was made for this spurious signal and none could be found. After a day of operation the flyout condition and spurious was detected at very low level. Continued running of the tube showed no increase in the strength of this instability. It is believed the tube does undergo some mechanical change which results in the excitation of this mode. It is not certain whether this phenomena is vacuum insert related or cavity related. It is probable the problem is cavity related. The level of this spurious signal is some -50 dB.

Figures 4.10 and 4.11 show the spectrum (note some odd lines show up on some of the photographs; these signals are not

TABLE 4.6

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1005.

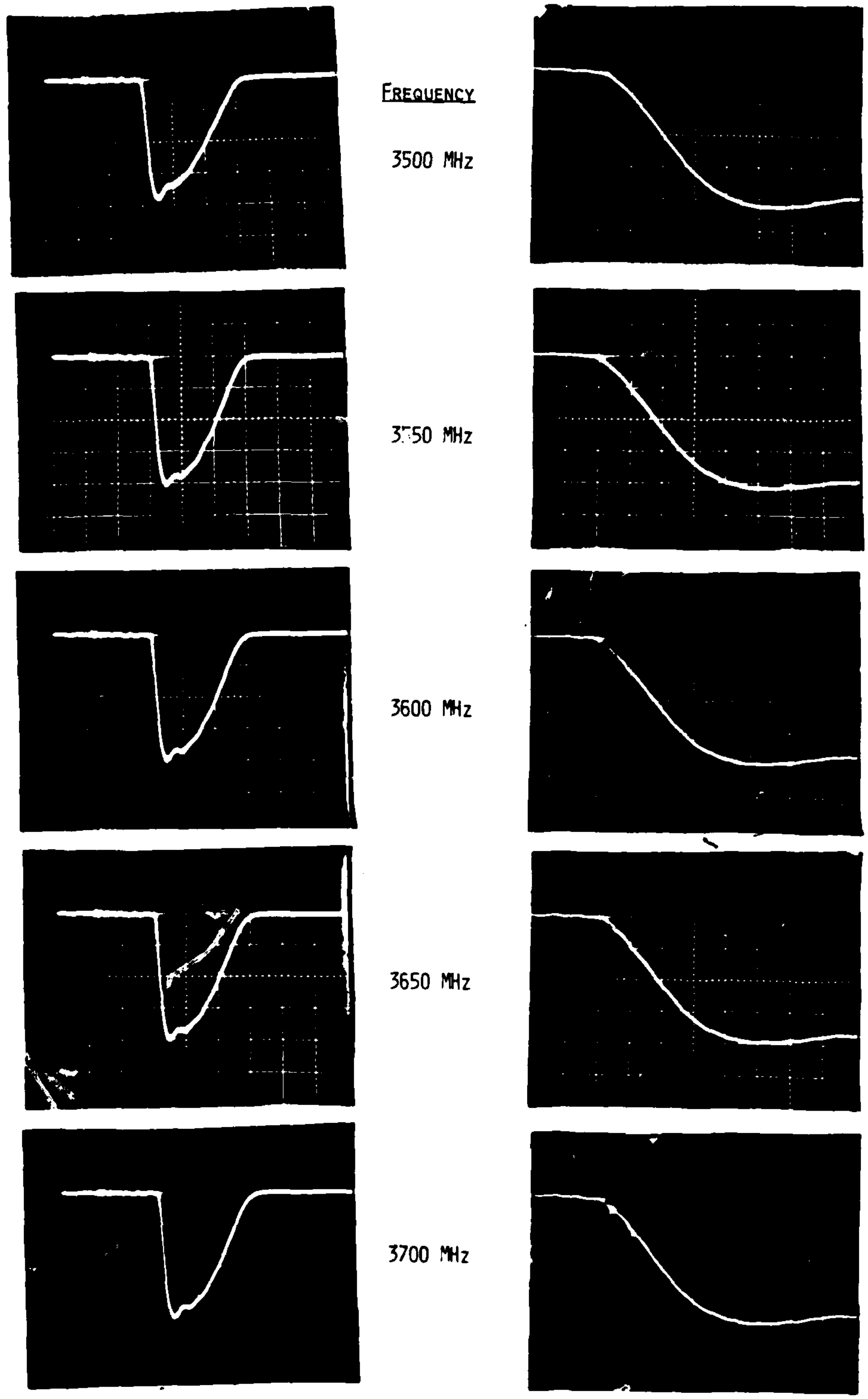
"A" CAVITY OPERATING IN SPN-43 TRANSMITTER CABINET

Test Date: June 19, 1980

Test Conditions: Pulse Width = 0.9 μs; Duty Cycle = 0.00086; Heater Voltage = 50 Volts; Current (Avg.) = 40 ma

Frequency (MHz)	Power (Avg.) (watts)	Power (Peak) (kilowatts)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Stability (%)	Jitter (ns)	Pushing KHz/A
3500	765	890	1.1	-12.0	0.00	1.0	16.0
3550	780	907	1.1	-11.0	0.00	0.8	17.0
3600	790	919	1.2	-11.0	0.00	2.0	18.0
3650	790	919	1.2	-11.0	0.00	1.5	16.0
3700	720	837	1.2	-11.5	0.00	1.2	17.0

June 19, 1980

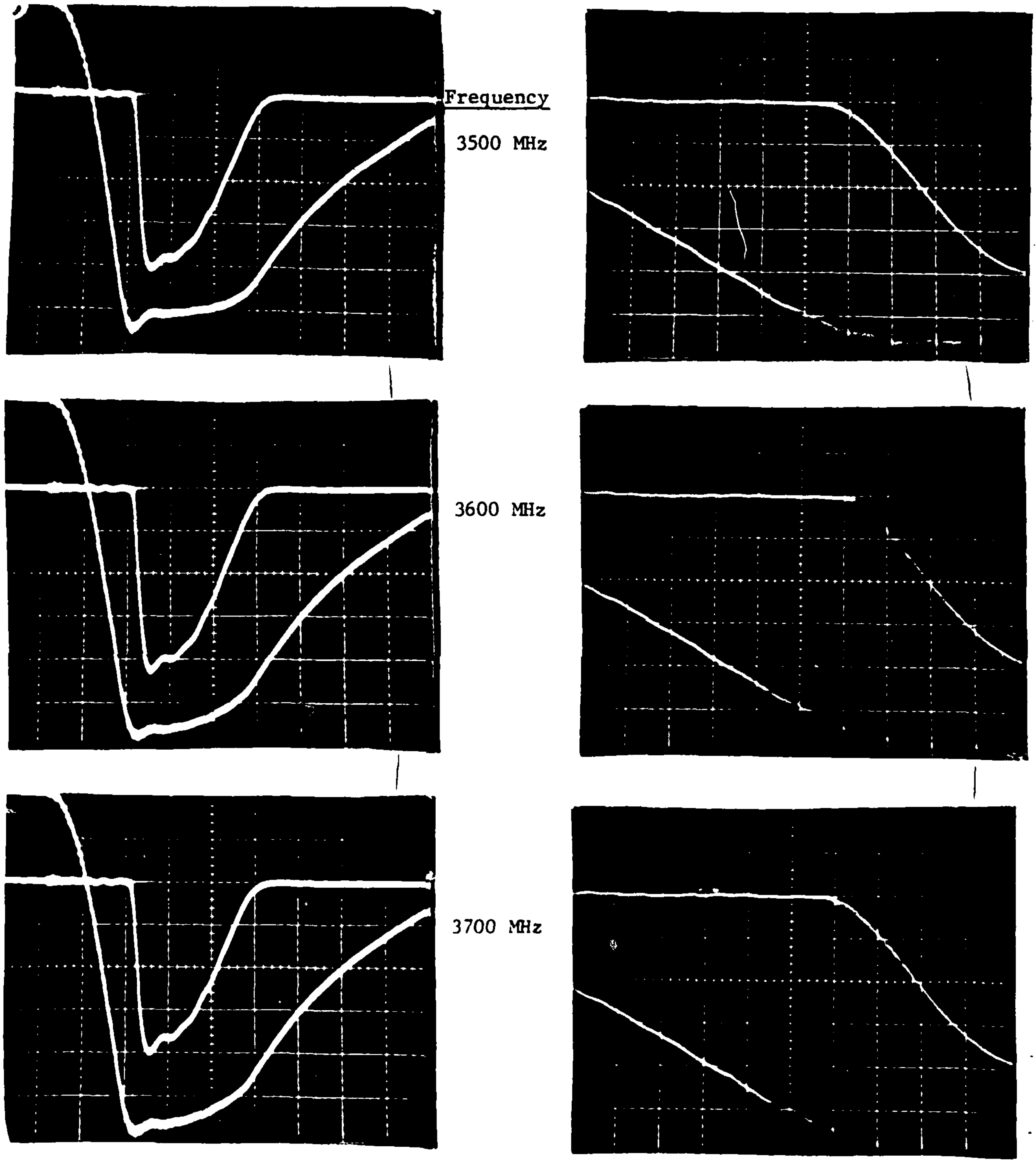


HORIZONTAL = 0.5 MICROSECOND/DIV. = 0.05 MICROSECOND/DIV.

FIGURE 4.8

DETECTED RF PULSE, VMS-1104, S/N 1005, "A" CAVITY

JUNE 18, 1980



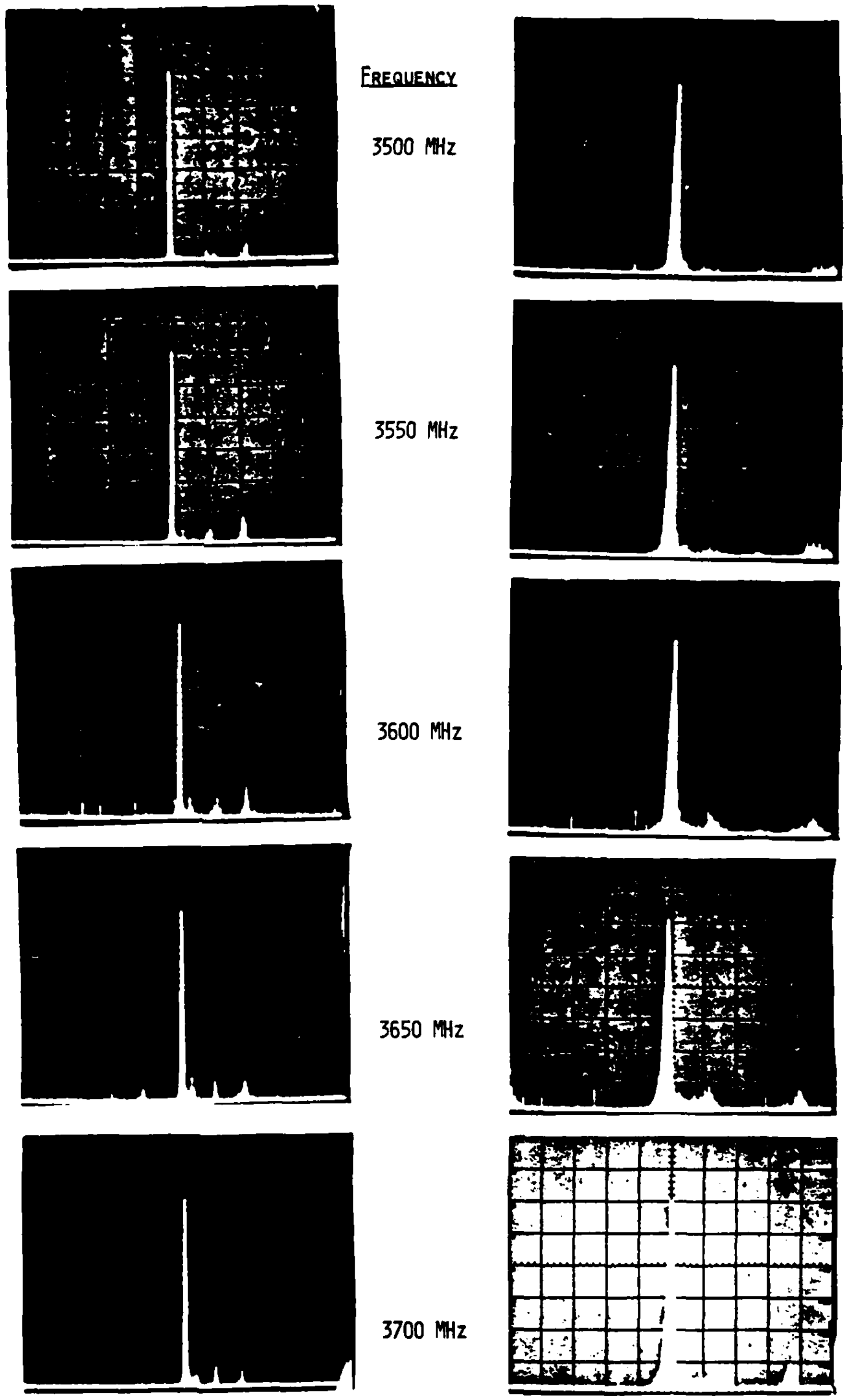
Horizontal = 0.5 μs/div. = 0.05 μs/div.

Vertical = 5 kV/div. (voltage)

FIGURE 4.9

Detected RF Pulse (upper trace) and Voltage Pulse (lower trace)

VMS-1104, S/N 1005, "A" Cavity

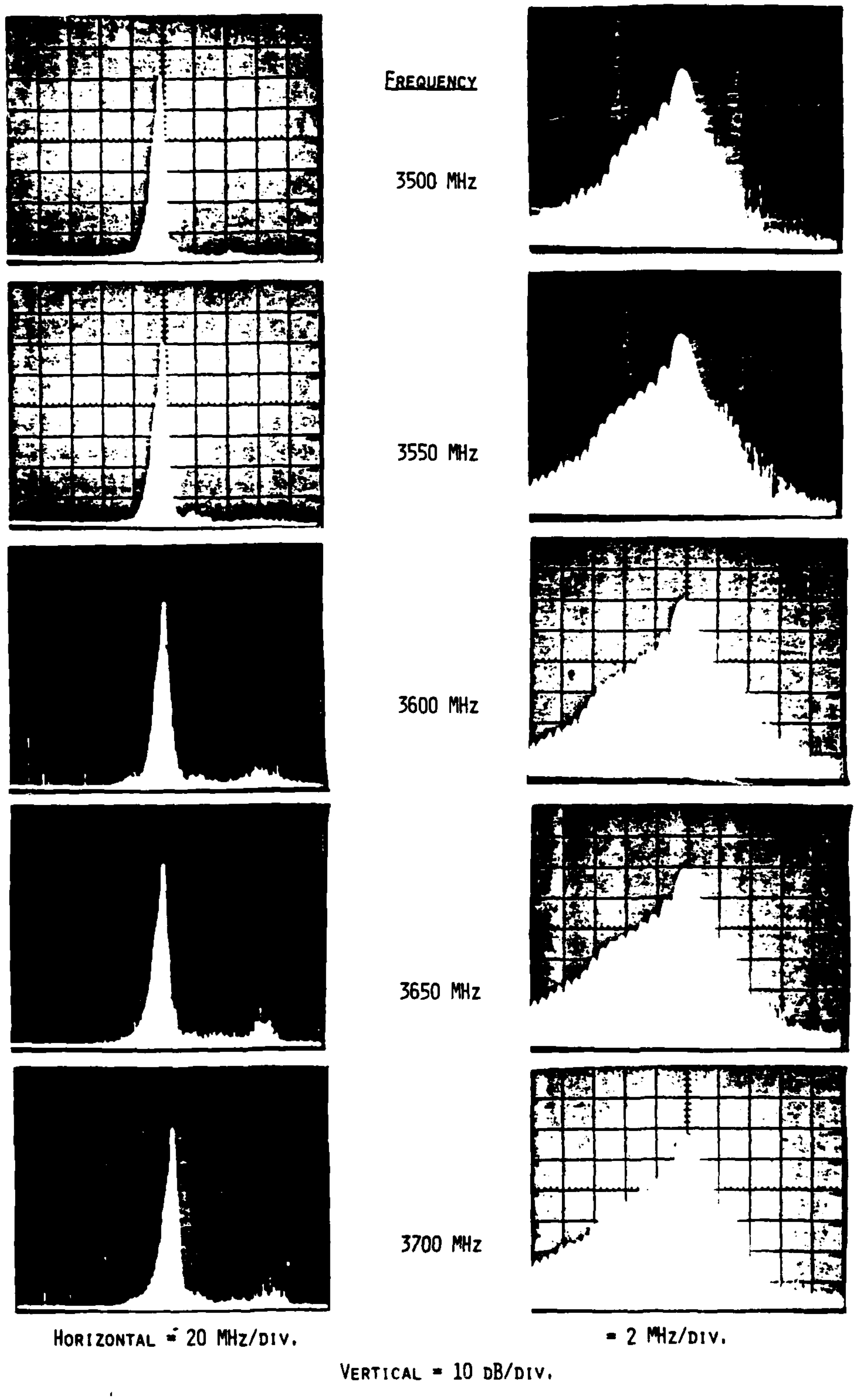


HORIZONTAL = 200 MHz/DIV. = 50 MHz/DIV.

VERTICAL = 10 dB

FIGURE 4.10

VMS-1104, S/N 1005, "A" CAVITY



Horizontal = 20 MHz/div. = 2 MHz/div.

Vertical = 10 dB/div.

Figure 4.11

VMS-1104, S/N 1005, "A" Cavity

June 18, 1980

generated within the magnetron, but are pick-up signals from adjacent test kits). Spurious level is -50 dB or better, and spectrum width at -40 dB is some 13 MHz.

The VMS-1104 tube (S/N 1005 insert and "A" cavity) demonstrated satisfactory performance both in the SPN-43 transmitter cabinet and in a test modulator with operation at the one megawatt peak, one kilowatt average power level. The tube was made available for shipment to a Navy site for test and evaluation.

4.2.1 Additional Data

The following data pertain to Band IV, VMS-1104 coaxial magnetron insert S/N 1005 and "A" cavity operating in the SPN-43 transmitter at Varian/Beverly.

a. Measurement of Anode-Cathode Capacitance

Capacitance measured across bushing terminal = 41.7 pf.

9/25/80

b. RF Pulse Width Check

Operation was at 40 ma average, and pulse repetition rate was 952 pps.

The pulse width was measured using two different attenuators.

Pulse Width (μs)

Frequency (MHz)	Attenuator (3 dB Variable)	Attenuator (3 dB Fixed)
3700	0.93	0.90
3600	1.00	0.93
3500	0.95	0.93

6/19/80

These measured values are within the system specification of 0.9 ± 0.15 μs. At 0.9 μs and 952 pps, the corresponding duty cycle is 0.00086 as specified for the system.

c. Tuning Data

Frequency and number of turns of the tuner drive shaft are given below. Data was taken under full power operation of the VMS-1104.

Counter	Frequency (MHz)
0	3500
10	3512
20	3524
30	3536
40	3548
50	3561
60	3574
70	3587
80	3601
90	3616
100	3630
110	3645
120	3660
130	3675
140	3691
146	3700

d. Summary of Tuner Characteristics

Tuner Torque (in-oz)

Frequency	CW	CCW
3500 MHz	23	20
3600 MHz	24	18
3700 MHz	22	19

Typical tuner torque of the motor in the SPN system is 30-40 in-oz.

Cold Torque Measurement

3600 MHz	9 oz-in	6 oz-in

Backlash

3500 MHz	42 KHz
3550	40
3600	75
3650	60
3700	100

6/20/80

e. Summary of Stop Performance

High Frequency Limit	3743 MHz
1 Revolution	3660
2 Revolutions	3590
3 Revolutions	3525
Low Frequency Limit	3478 MHz

6/18/80

f. Tube Cooling

At the time of installation of the support base for the tube, it was observed the air flow to the tube's cooling fins was both low and non-uniform. A series of measurements were made, and the support base subsequently modified such that the present flow to the fins is uniform and is approximately 40 ft^3/min.

The temperature of the tube was monitored at a number of locations and found to be in good agreement with data taken a

number of years ago. The body temperature of the tube is approximately 60°C.

4.3 Installation and Test of Standardized Coaxial Magnetron VMS-1104 in SPN-43 Radar at NESEA, Maryland

Date of Installation & Tests: June 30-July 3, 1980

Personnel:

NESEA	Mr. John M. Kreul, Field Maintenance Branch Head Mr. John Guy Mr. John Smith
NOSC	Mr. Robert Wills
Bendix	Mr. Robert Maneely, Field Engineer
Varian	Mr. Thomas E. Ruden Mr. Ken Wilson Mr. Paul Woodfin

Items Installed: One (1) standardized coaxial magnetron. VMS-1104 consisting of vacuum insert S/N 1005 and "A" cavity, and one (1) mod kit for the SPN-43 transmitter.

4.3.1 SPN-43 Mod Kit Parts List

Standardized Magnetron Insert

Standardized Magnetron Cavity

Complete Saddle Assembly

Saddle Insulator

Electrical Hot Box Assembly

Waveguide Assembly

Parker Seal (2)

Transformer

Transformer Bracket & Hardware

Coil & Bracket Assembly

Interlock Switch Plate & Hardware

Loading Yoke Assembly & Hardware

Loading Bars (2)

Tuner Drive Adapter Plate & Hardware

Air Switch Gasket & Hardware

Flexible Shaft

Boot Chute & Hardware
Transition Duct & Hardware
Air Duct & Hardware
Waveguide Airline Tee Assembly
Tank Valve
Bulk Head Fittings
Bulk Head Fittings Gasket & Hardware
Pressure Switch
Pressure Swtich Bracket & Hardware
Sealing Boot
Sealing Boot Clamp
Air Switch Nipple Assembly
Purge Hose Assembly
Main SF6 Hose Assembly
Switch/Waveguide Hose Assembly
Interlock Hose Assembly
Miscellaneous Hoses & Clamps & Fittings
Miscellaneous Hardware
Miscellaneous Waveguide Shims, Insulators & Gaskets

Size A tank of SF-6 also provide by Varian to NESEA site.

4.3.2 Summary of Installation and Test

Installation and test were made in the period of June 30 - July 1, 1980. Tube was operated at approximately full available power from the transmitter (36-37.5 ma level) with power being delivered to the antenna. The tube was tuned over the frequency range of 3500-3700 MHz with no indication of arcing or missing pulses. Visual inspection of the detected RF pulse indicated good starting characteristics of the magnetron. Tube would start and

operate stably when snapped on from the standby condition to the normal full power mode.

A mute test was run with a three-minute off time during which the heater level of the tube was maintained at the operate level. Upon snap on to full power the tube was stable.

Initial power measurements indicate the tube provided the required output power over the frequency range of 3500-3700 MHz.

Initial spectrum measurements showed spurious and spectrum consistent with that measured at Varian/Beverly--side lobes -10 dB or better, width at -40 dB of some 11 MHz, and spurious of some -50 dB or better at +250 MHz and other signals some -55 to -60 dB.

Overall installation of the mod kit was satisfactory.

4.4 Evaluation of Standardized Coaxial Magnetron VMS-1104 in SPN-43 Radar at NESEA, Maryland

Date of Tests: July 22-24, 1980

Personnel: NESEA Mr. John Guy
Mr. John Smith

Bendix Mr. Robert Maneely, Field Engineer

Varian Mr. Thomas E. Ruden

4.4.1 Introduction

The standardized coaxial magnetron, VMS-1104, S/N 1005 insert with cavity A was previously installed and operated in the SPN-43 transmitter at NESEA during the period of June 30-July 3, 1980. The tube was not operated during the interim period between initial installation and the present tests. A check of the gas pressure in the cavity showed approximately 5 psi indicating good sealing of the insert and cavity; the decrease in pressure from about 20 psi indicates some small leakage at the higher pressure levels. This may be cavity related or interconnection hose related. The gas pressure was increased to 20 psi with no indication of leakage.

Initial tests were made in the "adjustable" power mode. Operation below 35 ma showed the tube would follow the variation in input power to the transmitter at which point the de-Q circuit was not providing adequate control. Above 35 ma the de-Q circuit was operating satisfactorily, and the tube provided reproducible pulses. The tube had a smooth turn on with no arcing or other signs of

instability. Control was then switched to "normal" and operation continued at the 37 ma level.

Performance was checked at the 3500-3550 MHz range for any instability. None was observed. The tube was then tuned over the full band of 3500-3700 MHz several times, and spectrum and video photographs taken.

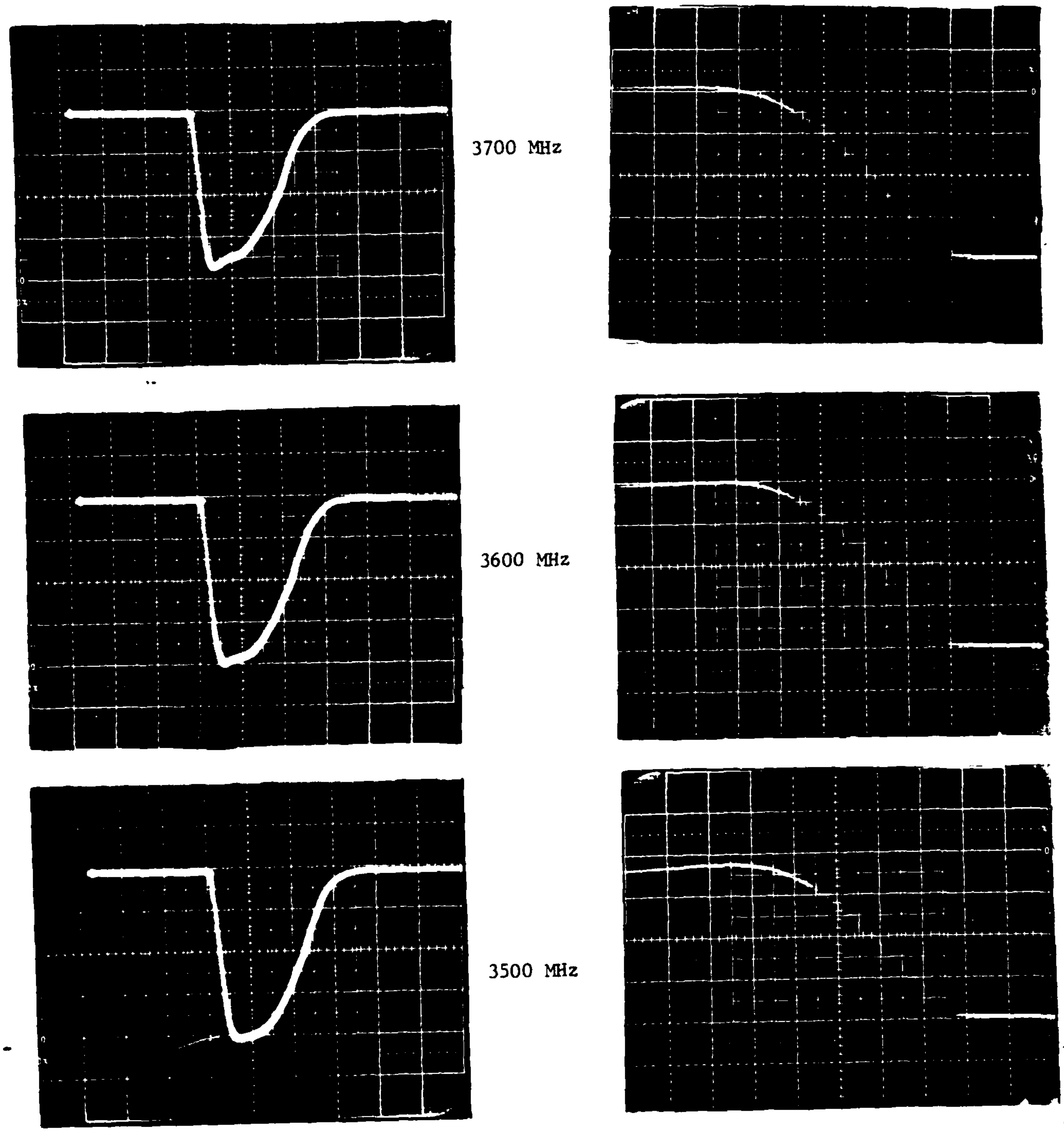
Figure 4.12 shows the detected rf pulse at 3700, 3600 and 3500 MHz. Similarity of pulse shape is apparent. The leading edge jitter was checked as shown in the accompanying photographs at 0.05 μs/division horizontal display. The peak-peak jitter is some 10 nanoseconds; the rms jitter is then about 2 nanoseconds. This value is in good agreement with that recorded at Varian.

Figures 4.13-4.17 show the recorded spectrum. Side lobe is 9-10 dB, spectrum width at -40 dB is some 11-12 MHz, and broad-band spurious is some -55 dB. These values are also consistent with those previously measured at Varian.

For general reference purposes, Figures 4.18 to 4.20 provide data on the current pulse, voltage rate-of-rise, voltage backswing, and linear representation of the spectrum.

Overall at the 38+ma level, the VMS-1104 coaxial magnetron performed exceptionally well in the modified SPN transmitter.

Some work was started on determining the effect of adding a smoothing capacitor to the d.c. power supply of the SPN transmitter. A marked improvement in the operation of the de-Q circuit was obtained. De-Q jitter was greatly reduced, and the current region over which

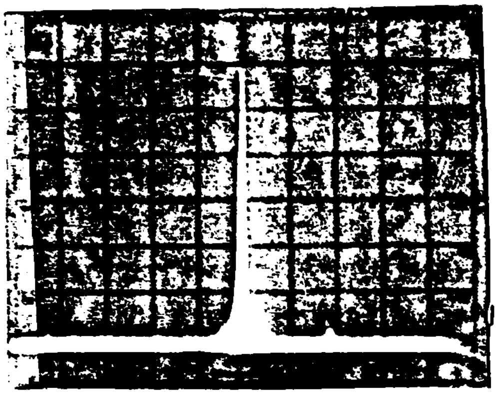


0.5 μs/div. 0.05 μs/div.

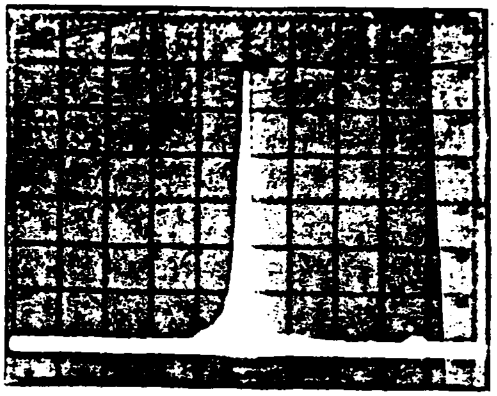
FIGURE 4.12

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

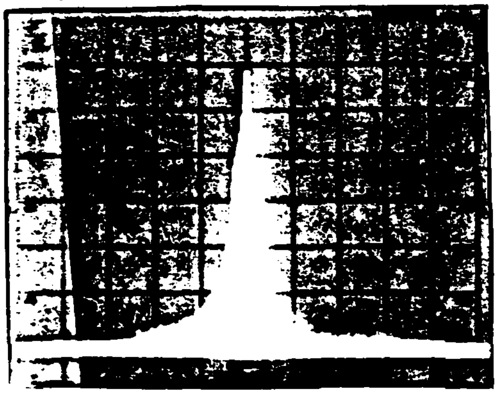
AN/SPN-43 NESEA, I_b = 38 ma



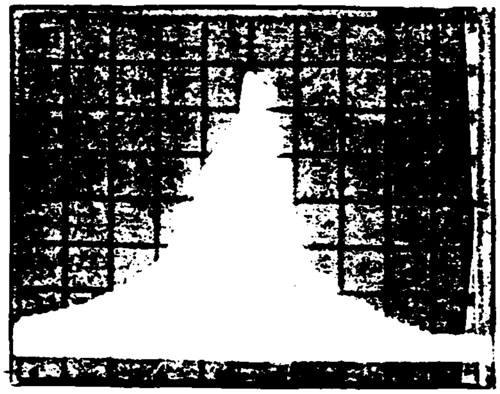
100 MHz/div.



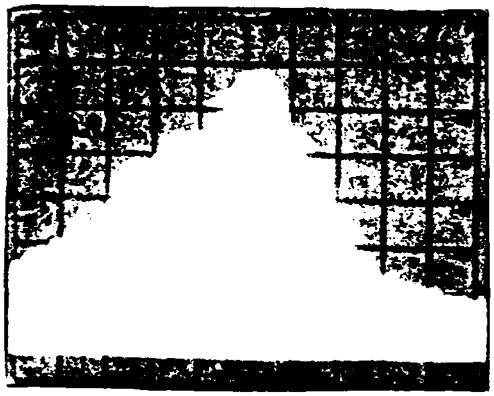
50 MHz/div.



20 MHz/div.



5 MHz/div.



2 MHz/div.

Vertical 10 dB/div., 100 KHz Resolution BW, 2 seconds Sweep/div.

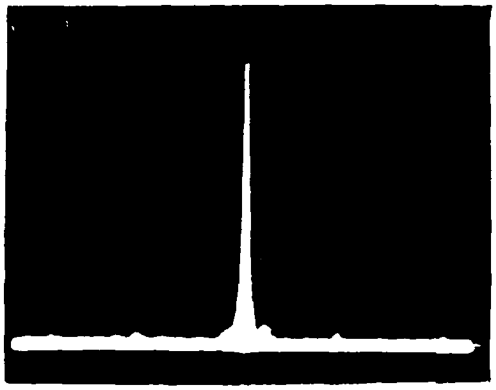
FIGURE 4.13

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

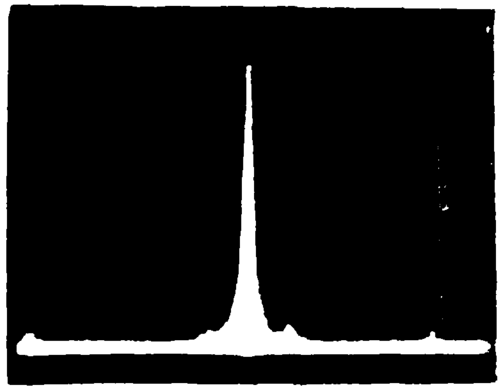
AN/SPN-43 NESEA

I_b = 38 ma; fo = 3700 MHz

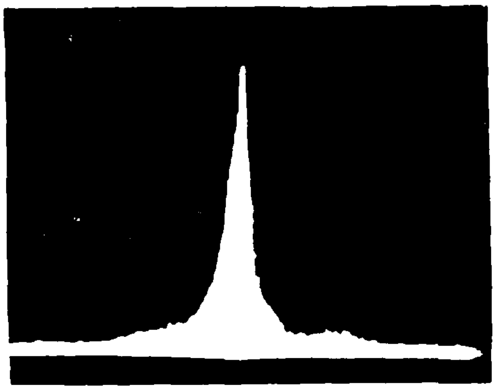
July 22, 1980



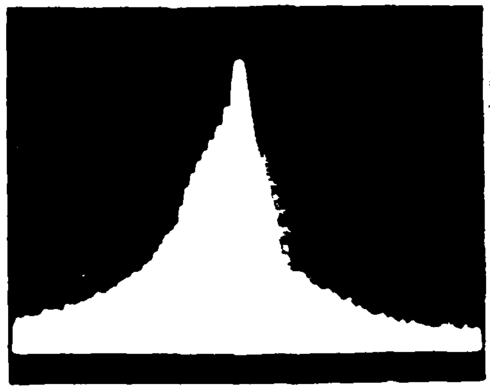
100 MHz/div.



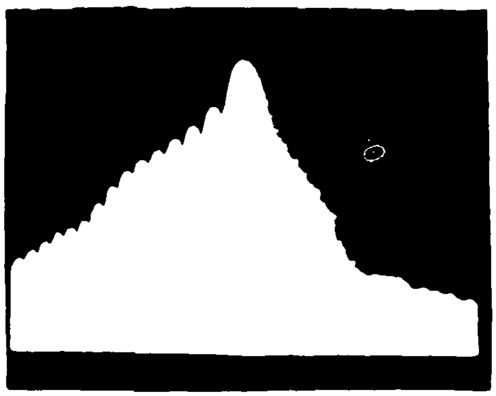
50 MHz/div.



20 MHz/div.



5 MHz/div.



2 MHz/div.

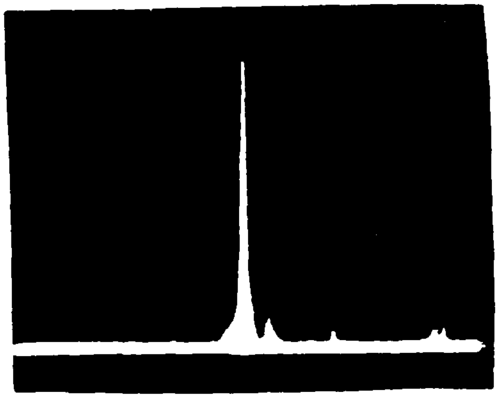
Vertical 10 dB/div., 100 KHz Resolution BW, 2 seconds Sweep/div.

FIGURE 4.14

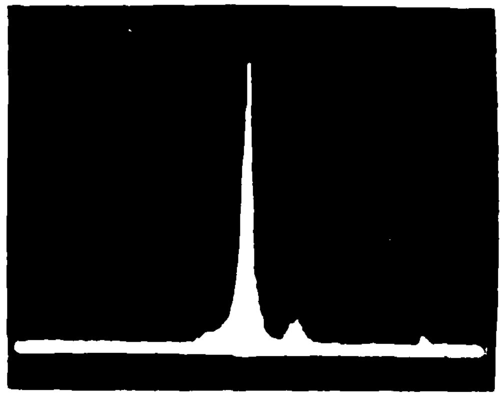
VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

AN/SPN-43 NESEA

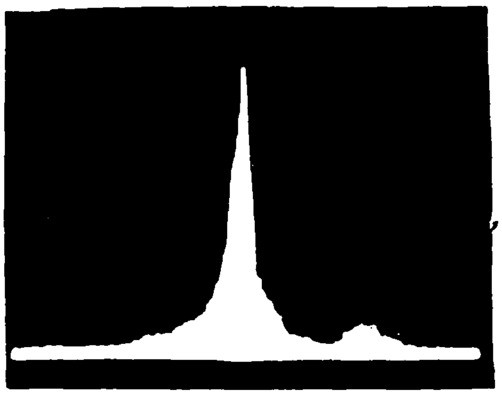
I_b = 38 ma; fo = 3650 MHz



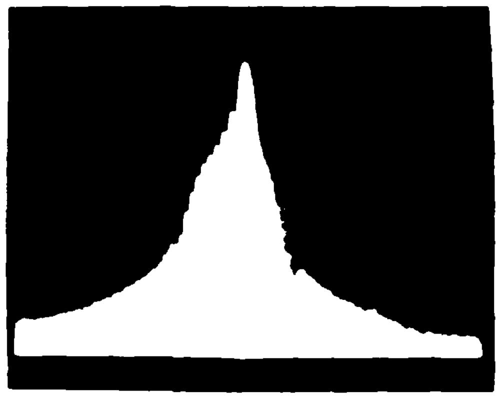
100 MHz/div.



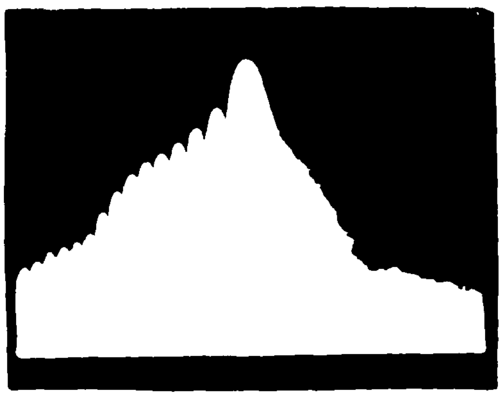
50 MHz/div.



20 MHz/div.



5 MHz/div.



2 MHz/div.

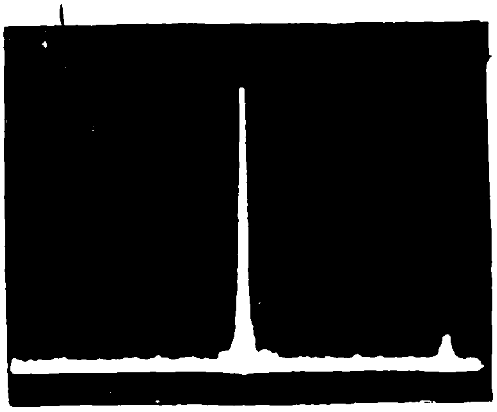
Vertical 10 dB/div., 100 kHz Resolution BW, 2 Seconds Sweep/div.

FIGURE 4.15

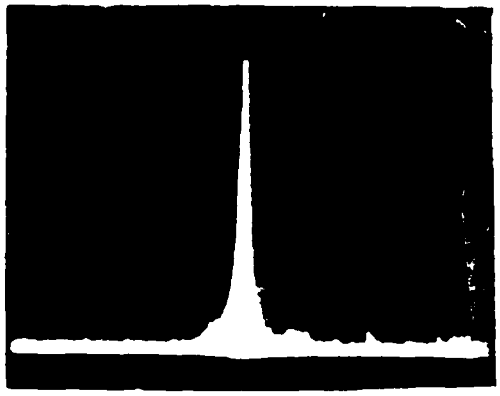
Standardized Coaxial Magnetron, VMS-1104, S/N 1005, Cavity A

AN/SPN-43 NESEA

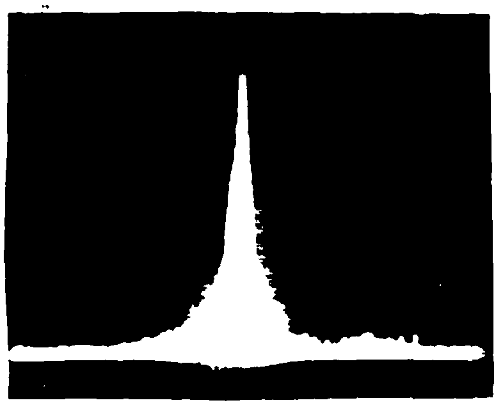
I_b = 38 ma, fo = 3600 MHz



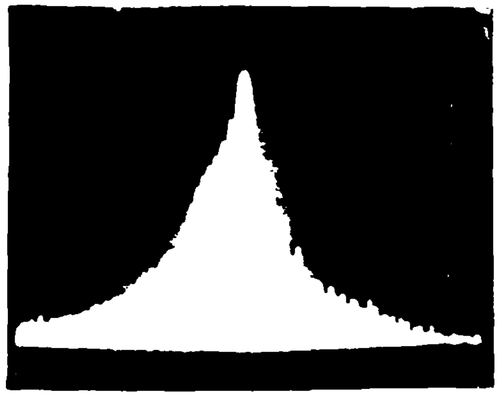
100 MHz/div.



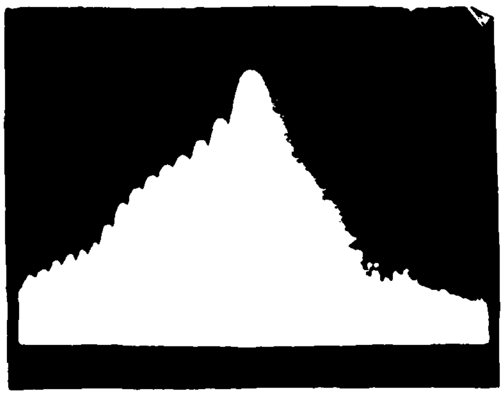
50 MHz/div.



20 MHz/div.



5 MHz/div.



2 MHz/div.

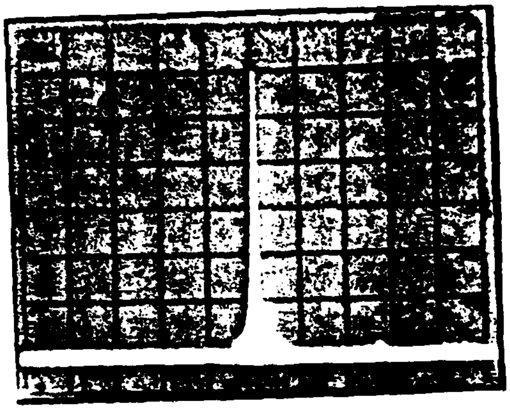
Vertical 10 dB/div., 100 KHz Resolution BW, 2 seconds Sweep/div.

FIGURE 4.16

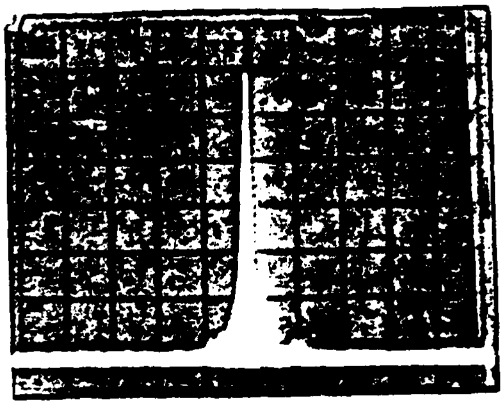
VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

AN/SPN-43 NESEA

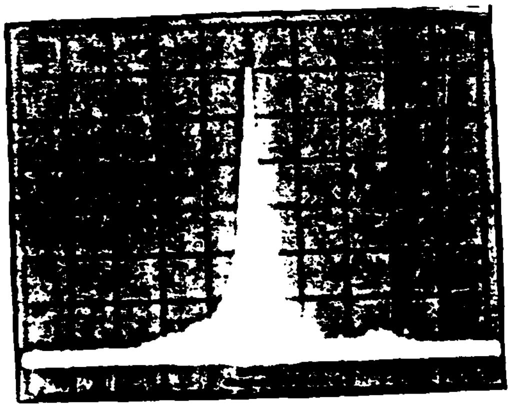
I_b = 38 ma; fo = 3550 MHz



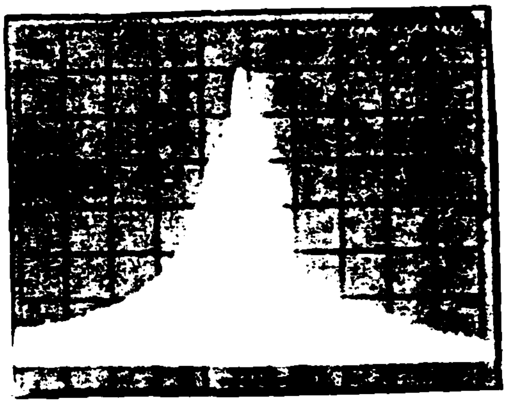
100 MHz/div.



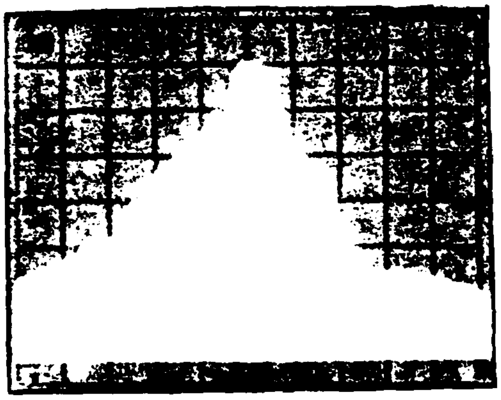
50 MHz/div.



20 MHz/div.



5 MHz/div.



2 MHz/div.

Vertical 10 dB/div., 100 KHz Resolution BW, 2 seconds Sweep/div.

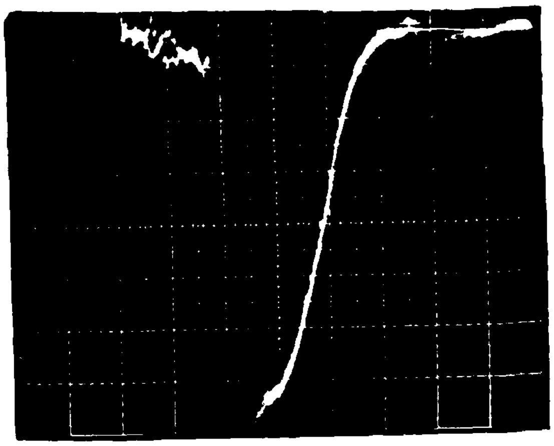
FIGURE 4.17

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

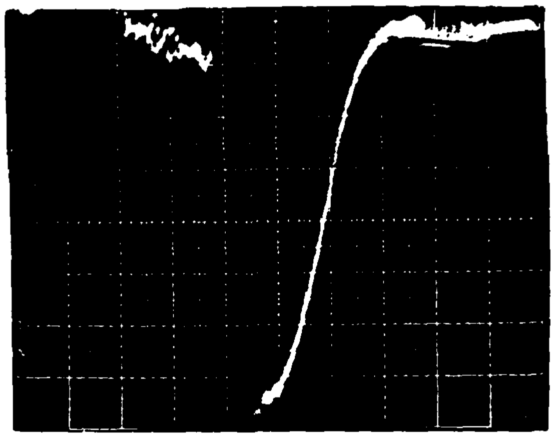
AN/SPN-43 NESEA

I_b = 38 ma; fo = 3500 MHz

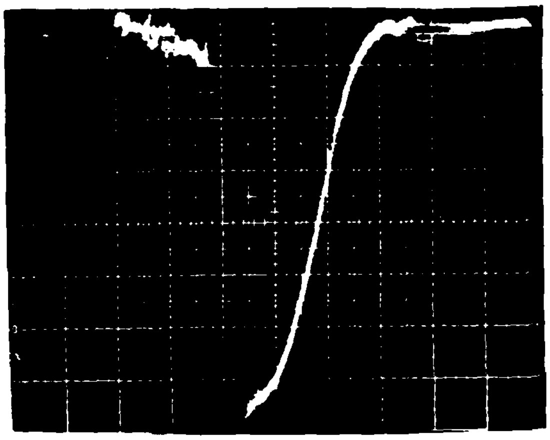
July 22, 1980



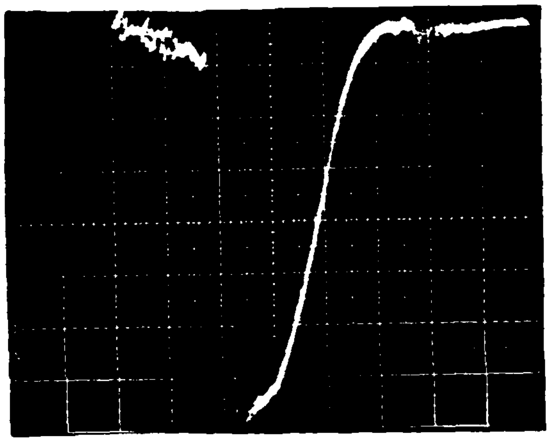
3700 MHz



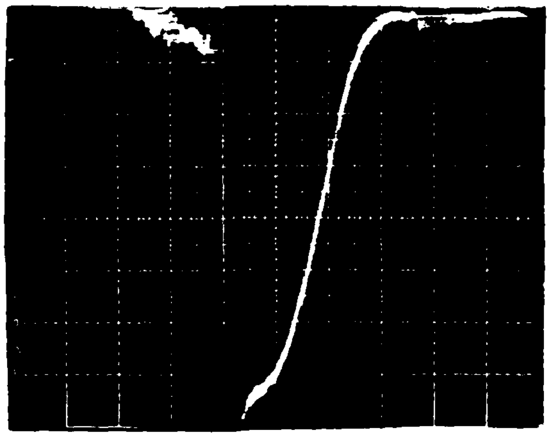
3650 MHz



3600 MHz



3550 MHz



3500 MHz

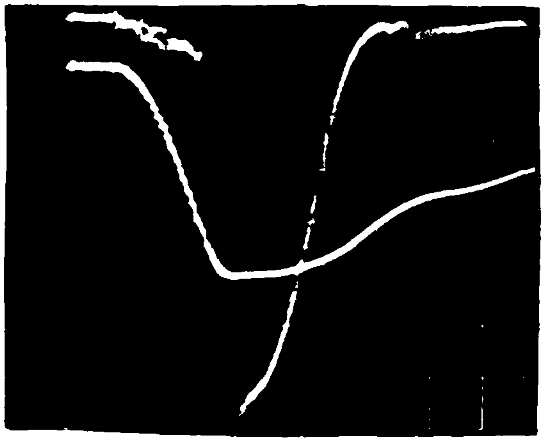
Vertical 5 V/div., 1 A/V Horizontal 0.5 μs/div.

FIGURE 4.18

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

AN/SPN-43 NESEA

Ib = 40 ma July 23, 1980



fo = 3600 MHz

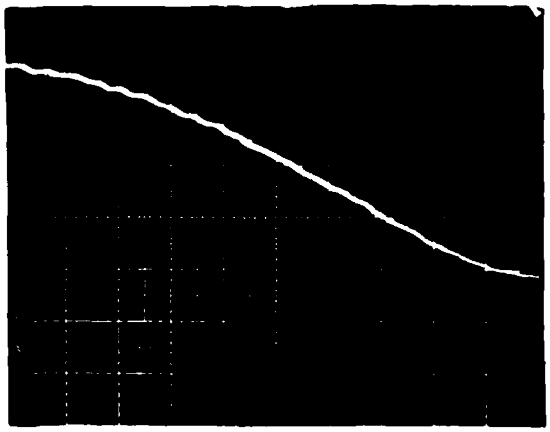
I_b = 38 ma

Vertical

Current 5 V/div., 1 A/V

Voltage ~ 10 kV/div.

Horizontal = 0.5 μs/div.



fo = 3600 MHz

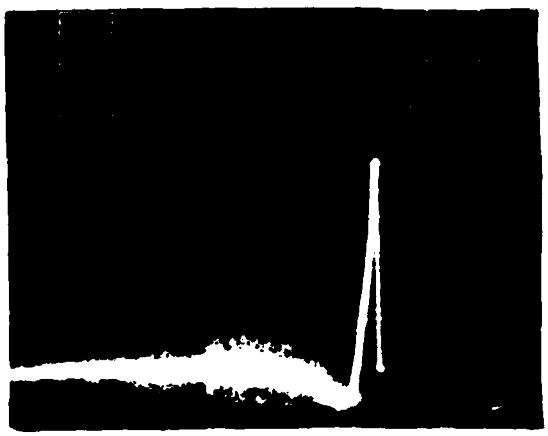
I_b = 38 ma

Vertical

Voltage ~ 10 kV/div.

Horizontal = 0.1 μs/div.

rrv ~ 57 kV/μs



fo = 3600 MHz

I_b = 38 ma

Vertical

Voltage ~ 10 kV/div.

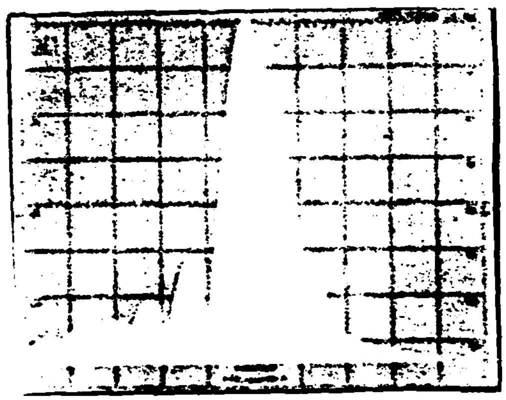
Horizontal = 20 μs/div.

Backswing ~ 7 kV

FIGURE 4.19

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

AN/SPN-43 NESEA



1 MHz/div.

Vertical - Linear, 30 kHz Resolution BW, 2 Sec. Sweep/Div.

FIGURE 4.20

VMS-1104 Coaxial Magnetron, S/N 1005, "A" Cavity

AN/SPN-43 NESEA

I_b = 40 ma; fo = 3700 MHz

the circuit excites tube instability was reduced from the 35 ma level to the 25 ma level. Further improvements in the de-Q circuit response may be possible by optimizing the value of the filter capacitor or via the inclusion of a suitable smoothing choke in the d.c. line.

Cavity pressure holding was checked on two subsequent nights. With the SF-6 tank valved off, the cavity pressure would drop from 20+psi to some 16-19 psi overnight. This indicates the overall sealing of the cavity is good, but some minor leakage is present. This leakage may be associated with the various hose connections. Note under the above conditions it is not required to purge the cavity to run the tube to full power. The SF-6 valve is simply opened to provide the desired cavity pressure, and the tube placed in operation.

We did observe corona arcing at a mod-kit coil support after the transmitter had been placed in standby condition overnight. The transmitter cabinet was very wet inside due to condensation of moisture. The addition of a connecting lead from the end of the coil to a support bracket suppressed the corona and arcing. No corona or arcing was observed at the high voltage bushing of the tube. In the hot box some minor corona was seen at a high voltage lead connection point.

Correction of the observed corona activity may involve either minor changes to the manner of making the connections or to the use of dielectric coatings on the specific component.

4.4.2 Power Measurement

SPN-43 coupler plus cable coupling factor:

Frequency (MHz)	Factor (dB)
3500	54.0
3600	53.0
3700	53.8

Measured power level:

Frequency (MHz)	ib (ma)	P (relative) (dB)	ib (ma)	P (relative) (dB)
3500	39	58.3	43	58.9
3600		57.3		57.9
3700	38	57.9	42.5	58.5

We observe a reduction in output power at 3600 MHz. This is not in accord with power measurements made at Varian/Beverly into a water load both on the SPN and in a test kit. Requires check of insertion loss of system isolator, coupler and cables.

4.4.3 Record of Operating Time: S/N 1005, Cavity A at NESEA

	No. of Hours	
Date	Standby	Radiate
7/1-7/2-80	3.0	11.5
7/22-7/24/80	21.9	15.8
Total	24.9	27.3

4.4.4 SPN-43, NOSC Test

Test and evluation of the VMS-1104 coaxial magnetron in the SPN equipment was coordinated with a series of tests run by NOSC personnel in the SPN radar system. These tests were made over the time period of July 22-24, 1980.

4.4.5 Performance of Tube and Mod Kit Since Installation

The following paragraphs summarize the performance of the tube and the mod kit since installation based on telephone conversations with the NESEA personnel. The removal of the tube and mod kit from the system to allow test of the conventional magnetron is also described.

Date	Comment or Action Taken
8/29/80	Overall operation of the tube satisfactory. Observe some drop off in cavity pressure when the SF_6 tank is sealed off. Long term pressure about 5 psig. No purge required when tube is placed back into operation.
10/20/80	Overall satisfactory operation, but drop in cavity pressure is much faster. Added two microfarad capacitor to power supply per tests of 7/80. Tube ran to 55 ma level; de-Q circuit adjusted to give 40 ma. Observe some corona at coil.
10/23/80	NESEA personnel adjusted in cavity boot seal clamps and resealed the cavity. Cavity purged, and tube was operated at full power without difficulty. Tube operated at 47-48 ma level with 2.0 mfd capacitor in system. System inadvertently run without cooling water; transmitter and tube ran hot, and pressure

Date	Comment or Action Taken
	increased to some 30 psig. Retest showed no degradation in tube performance.
1/28/81	Tube performing satisfactorily; recent system tests performed. Slight cavity pressure drop off overnight and during weekend. Simple addition of gas to the cavity restores pressure. Necessary to remove the tube from the system to test conventional tube.
1/30/81	Varian personnel (K. Wilson and P. Woodfin) assisted NESEA in the removal of the VMS-1104 tube and mod kit components from the SPN-43 system and assisted in restoring the system to its original configuration. Operating time, based on meter readings, was radiate: 105 hours; standby: 532 hours.

Visual inspection of the VMS-1054 and mod kit components was made:

a. VMS-1104--no sign of arcing at high voltage terminal.

b. Hotbox--no arcing.

c. Modulator Inductor--sign of corona, minor arcing at the ends of the coil-support clip. (During tests of July 23-24 had previously added jumper wires from the end of the coil to the clip to reduce corona.)

d. Waveguide Components: insulator--no arcing; flexguide--no arcing; Parker seal--minor arc marks.

4.5 Full Power Test of Band IV Tube, VMS-1104, S/N 1007R and S/N 1008

Test of vacuum inserts S/N 1007R and S/N 1008 was performed using the Varian test modulator, K-277. Modulator voltage rate-of-rise was adjusted via the use of an R-C network on the output of the pulse transformer. Note the pulse transformer used in the test of S/N 1005 had failed during the interim period; present transformer has different turns ratio and thus somewhat different characteristics. The added R-C network was adjusted for acceptable pulse shape at reasonable rate-of-rise of voltage (some 50 kV/μs). The fall time of the pulse is not optimum and could be reduced by changing the impedance of the pusle forming network.

4.5.1 S/N 1007R

The VMS-1104 "B" cavity was employed to test both vacuum inserts. Table 4.7 provides the data obtained on insert S/N 1007R taken at a duty cycle of 0.001 with a 1.9 μs pulse. The tube demonstrated excellent coaxial magnetron performance in terms of missing pulse stability and leading edge time jitter on the rf pulse. The general video performance is given in Figures 4.21 and 4.22 showing detected rf pulse and current pulse at frequencies from 3500-3700 MHz. Figure 4.23 provides photos of the rf, current and voltage with expanded horizontal scale.

Figure 4.24 shows the level of spurious signal generation measured over a frequency range of 500 MHz on either side of the main oscillation. Overall the spurious level is better than 50 dB below the main signal.

Figure 4.25 shows the spectrum at a horizontal display of 2.0 MHz/div.

Figure 4.26 depicts the time growth of the TE_{121} signal at the high end of the tuning range (3680-3690 MHz), and Figure 4.27 shows the TE_{121} signal at 3700 MHz after 10 and 30 minutes of operation. The stable spurious level of this mode is better than -50 dB.

Figure 4.28 provides additional data on the stability of the TE_{121} mode with respect to heater power. Operating the tube at zero heater power (emission is sustained by the back bombardment power and by secondary emission) shows reduced spurious generation.

Final test of this tube on the K-277 test modulator was made on March 19, 1981. Video and spectrum performance were in accord with that recorded above; operating performance is given in Table 4.8. Overall performance is in good agreement with that of Table 4.7.

TABLE 4.7

TEST RESULTS BAND IV COAXIAL MAGNETRON, VMS-1104

S/N 1007R, CAVITY B

Test Modulator K-277: I_{avg} = 55 ma; tpc = 1.9 μs; duty = 0.001, V_f = 30 volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Missing Pulses (%)	Pulling (MHz)	Pushing (KHz/amp)	Leading Edge Jitter (ns)	
								(1)	(2)
3500	39.0	1020	0.6	11	0.0	1.0	10	3.9	4.9
3550	39.6	1040	0.6	11	0.0	1.0	10	3.4	3.9
3600	39.8	1100	0.6	10	0.0	1.4	10	3.2	3.4
3650	40.0	1100	0.55	11	0.0	1.5	20	3.4	3.9
3700	40.2	1020	0.6	10	0.0	1.5	16	3.4	4.4

(1) Matched load.

(2) 1.5 VSWR, Worst Phase

March 13, 1981

TABLE 4.8

Test Results, E nd IV Coaxial Magnetron, VMS-1104

S/N 1007R, Cavity B

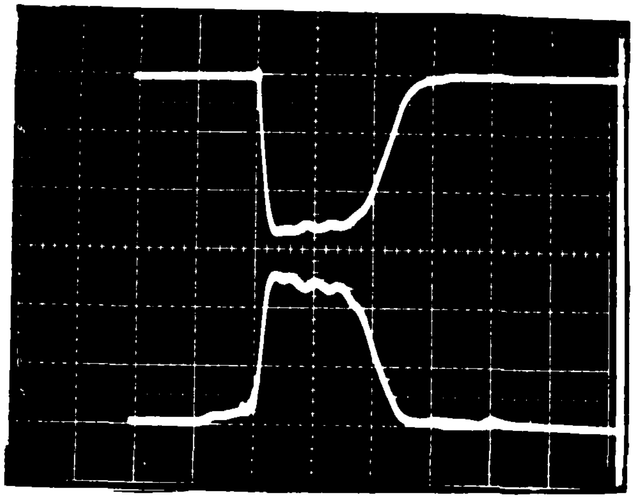
Test Modulator K-277; I_{avg} = 55 ma; tpc = 1.9 μs; duty = 0.001; V_f = 30 volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Missing Pulses (%)	Pulling (MHz)	Pushing (kHz/amp)	Leading Edge Jitter (ns)	
								(1)	(2)
3500	39.0	1180	0.6	11	0.0	1.0	10	4.4	5.4
3600	40.0	1290	0.6	10	0.0	1.3	9	3.5	3.9
3700	40.5	1160	0.6	10	0.0	1.3	20	3.9	4.5

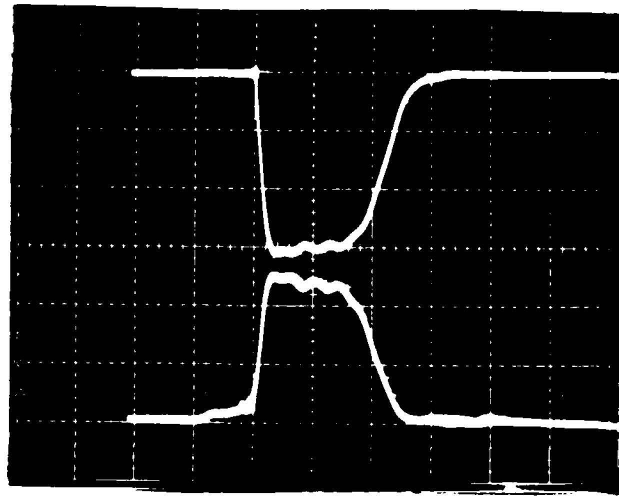
(1) Matched Load

(2) 1.5 VSWR, Worst Phase

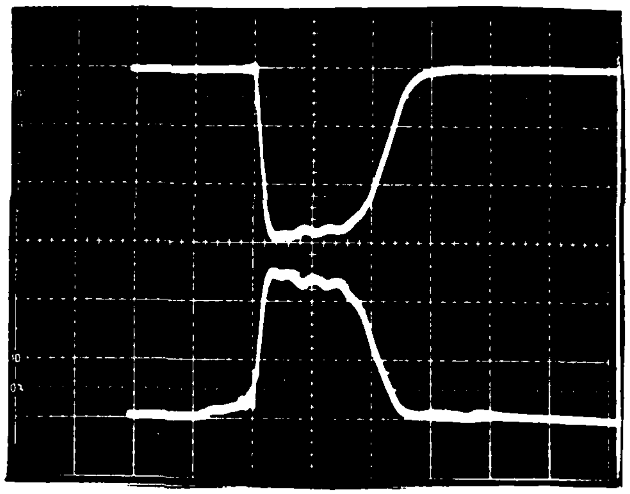
March 19, 1981



3700 MHz



3650 MHz



3600 MHz

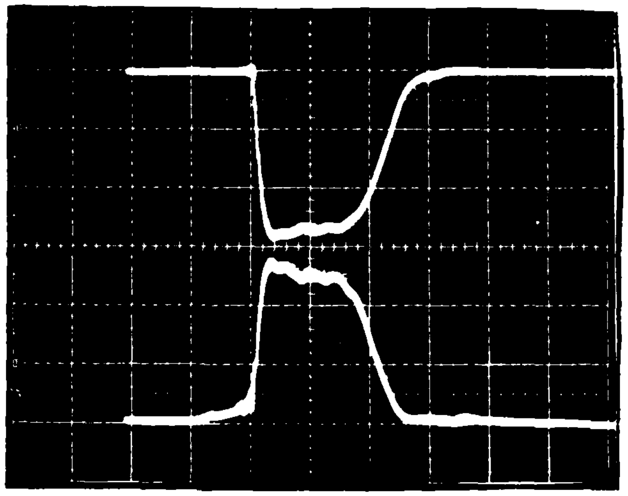
1.0 μs/div.

Top Trace: Detected RF Pulse   Bottom Trace: Current Pulse (vertical 20 A/div)

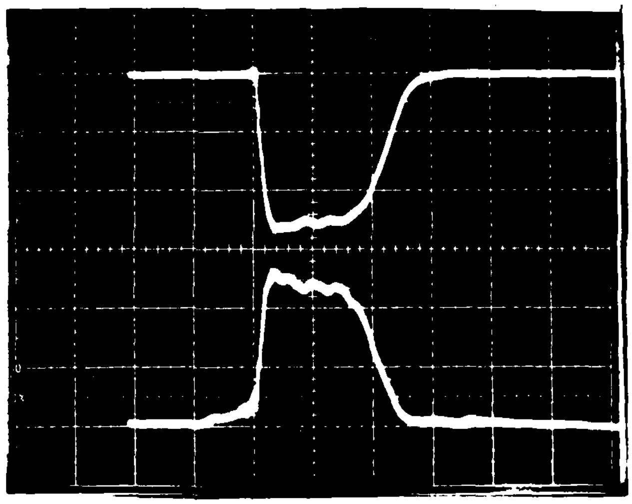
FIGURE 4.21

VMS-1104, S/N 1007R, Test Modulator K-277

I = 55 ma (average); Duty = 0.001



3550 MHz



3500 MHz

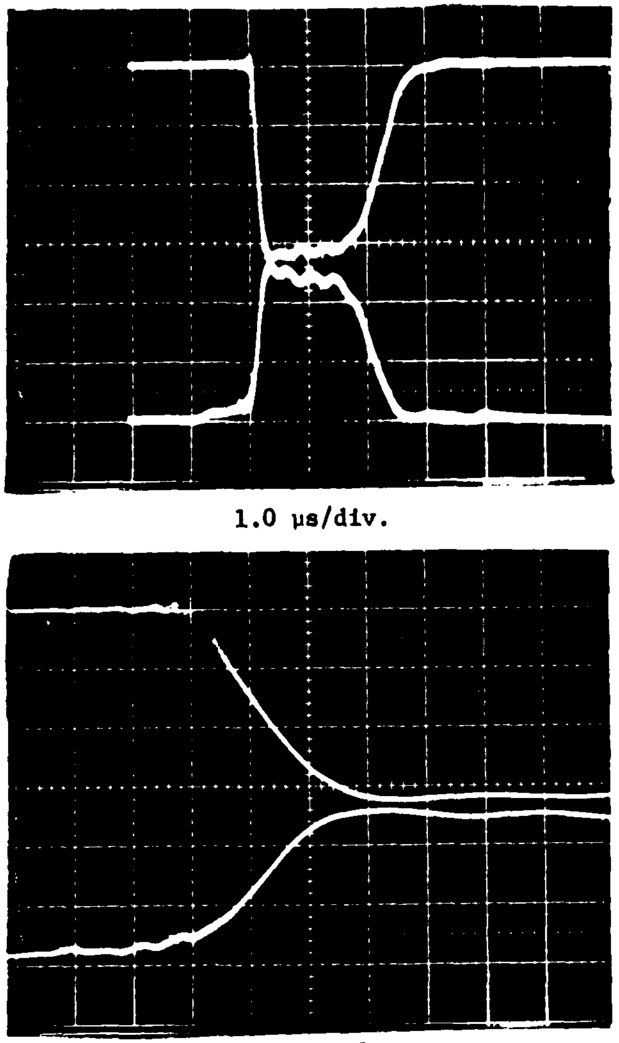
1.0 μs/div.

Top Trace: Detected RF Pulse Bottom Trace: Current Pulse (vertical 20 A/div)

FIGURE 4.22

VMS-1104, S/N 1007R, Test Modulator K-277

I = 55 ma (average); Duty = 0.001

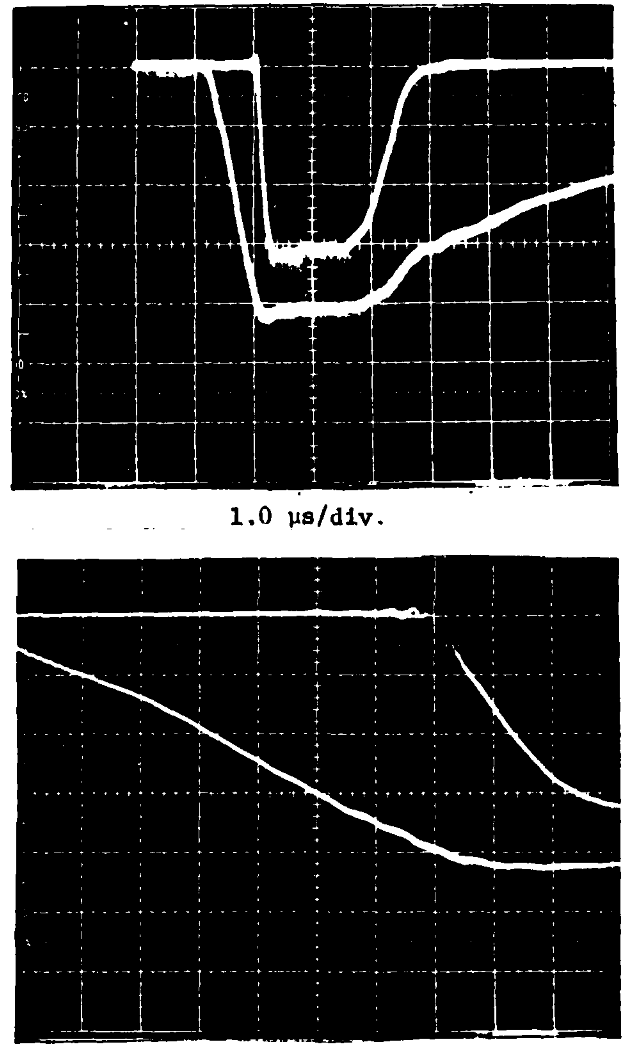


1.0 μs/div.

0.1 μs/div.

Top Trace: Detected RF Pulse

Bottom Trace: Current Pulse (vertical 20 A/div)



1.0 μs/div.

0.1 μs/div.

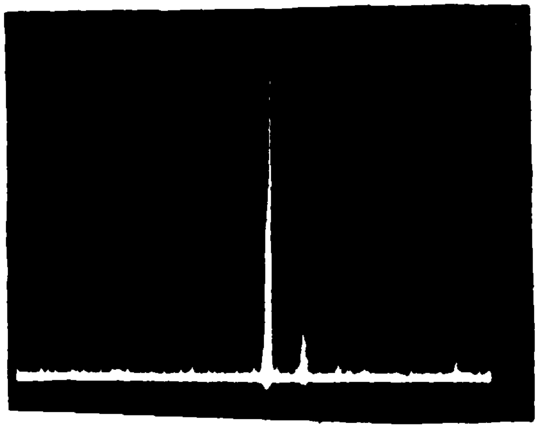
Top Trace: Detected RF Pulse

Bottom Tracé: Voltage Pulse (vertical 10 KV/div)

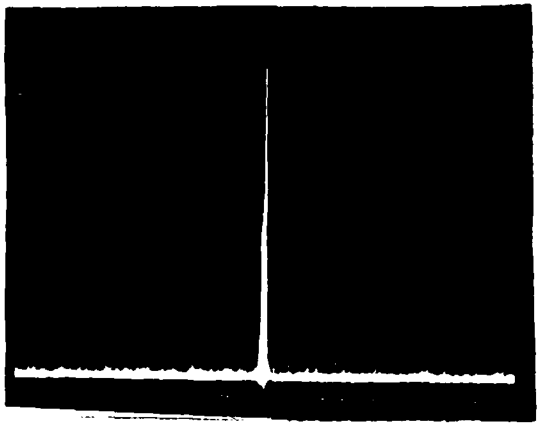
FIGURE 4.23

VMS-1104, S/N 1007R, Test Modulator K-277

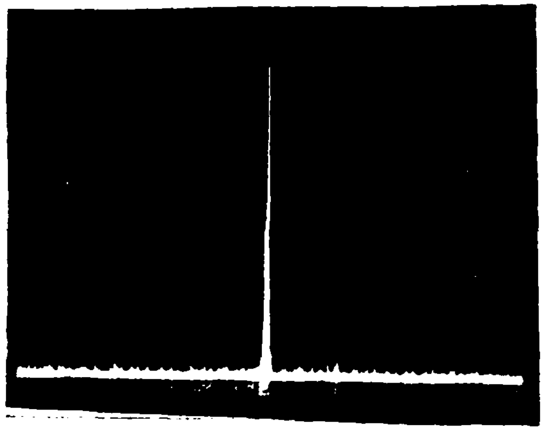
I = 55 ma (average); Duty = 0.001



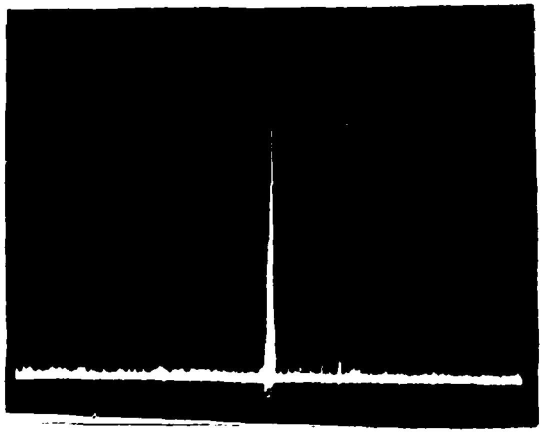
3700 MHz



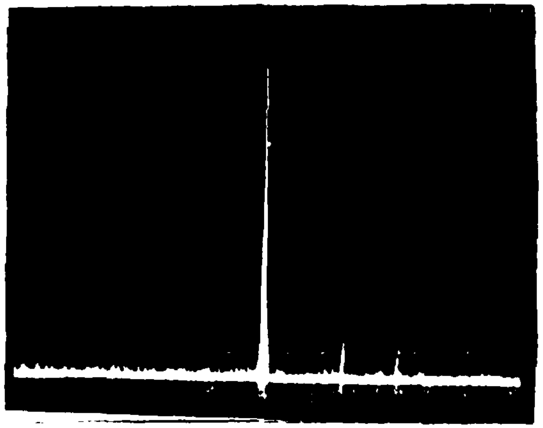
3650 MHz



3600 MHz



3550 MHz



3500 MHz

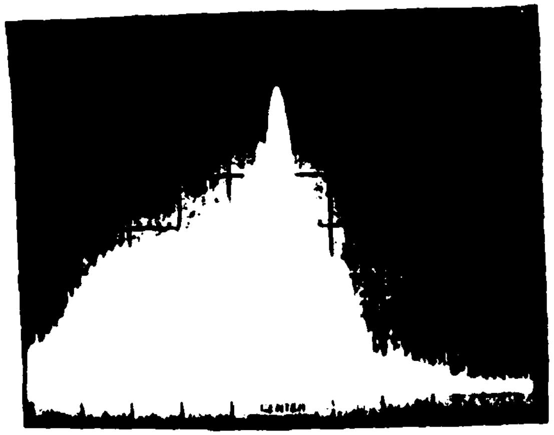
Vertical = 10 dB/div. Horizontal = 100 MHz/div.

FIGURE 4.24

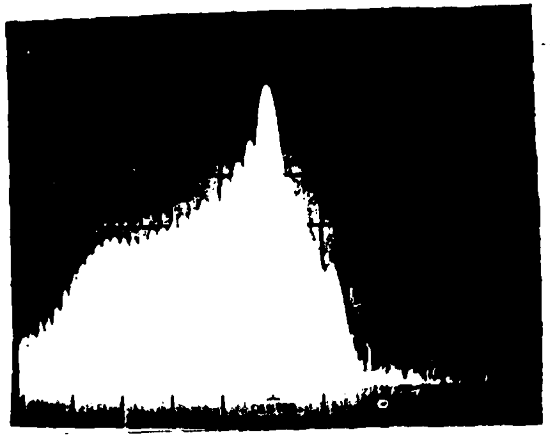
Standardized Coaxial Magnetron, VMS-1104, S/N 1007R, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 µs; Duty = 0.001; Vf = 30 volts

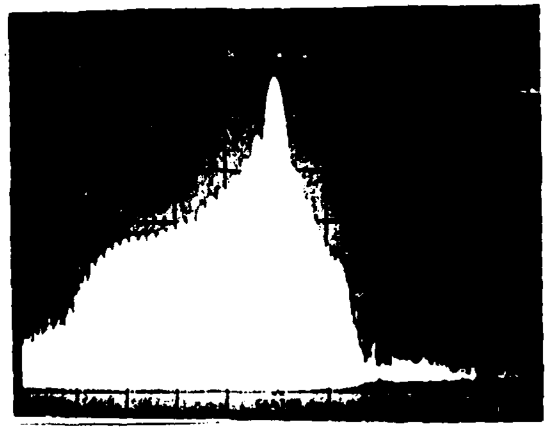
March 13, 1980



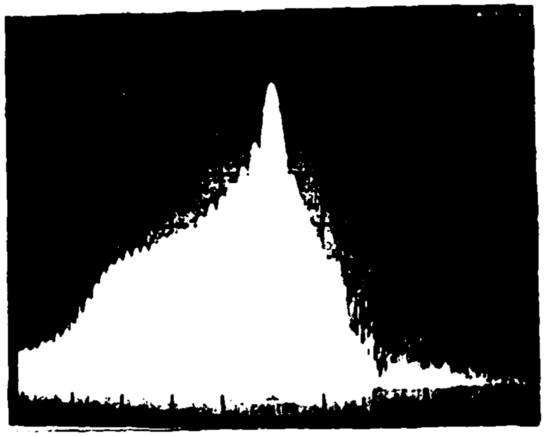
3700 MHz



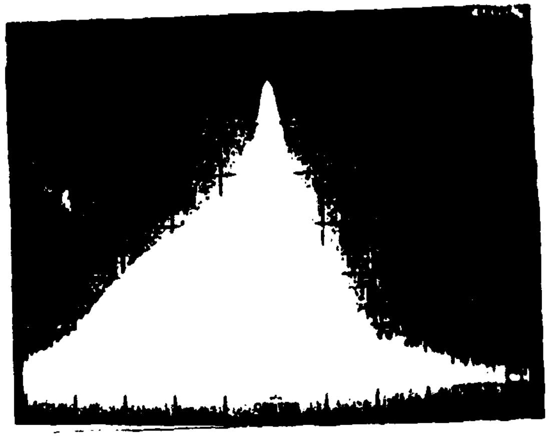
3650 MHz



3600 MHz



3550 MHz



3500 MHz

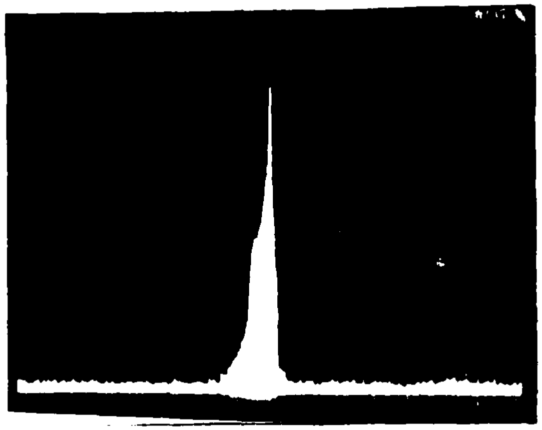
Vertical = 10 dB/div.

Horizontal = 2.0 MHz/div.

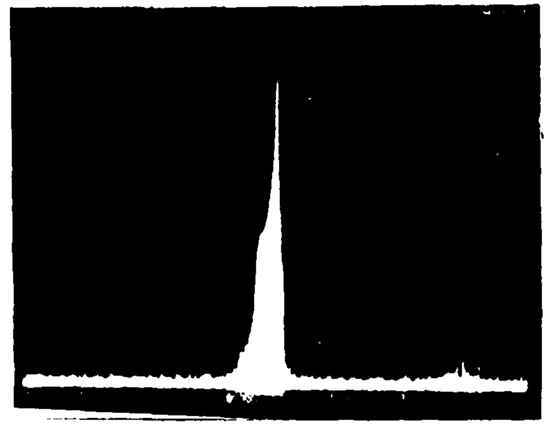
FIGURE 4.25

Standardized Coaxial Magnetron, VMS-1104, S/N 1007R, Cavity B, Test Modulator K-277

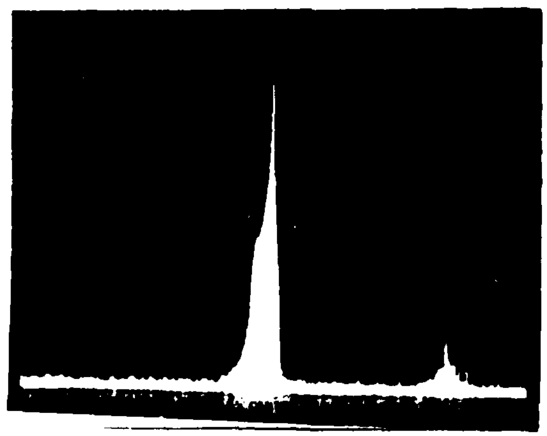
I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; Vf = 30 volts



3680 MHz Turn On



3680 MHz (30 minutes)



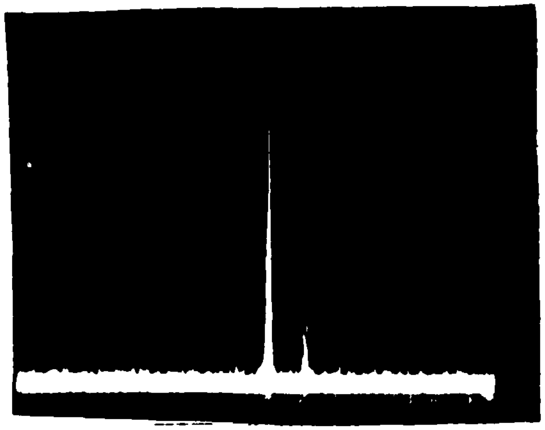
3690 MHz (30 minutes)

Vertical 10 dB/div.   Horizontal = 20 MHz/div.

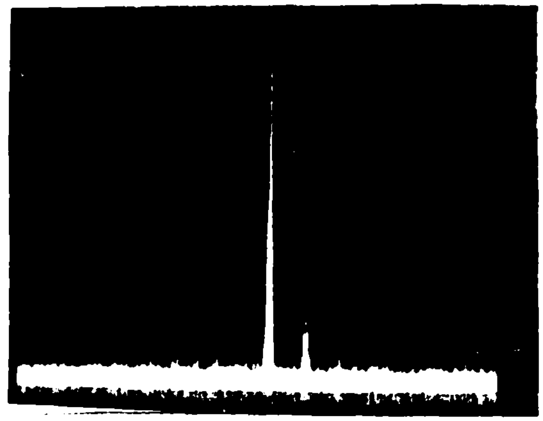
FIGURE 4.26

Standardized Coaxial Magnetron, VMS-1104, S/N 1007R, Cavity B, Test Modulator K-277

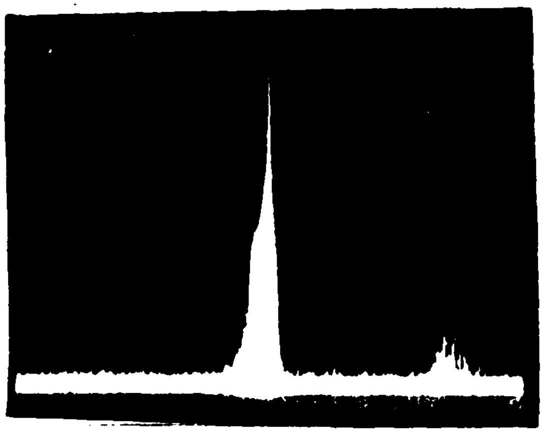
I_{avg} = 55 ma; tpc = 1.9 us; Duty = 0.001, V_f = 30 volts



100 MHz/div. (10 minutes)

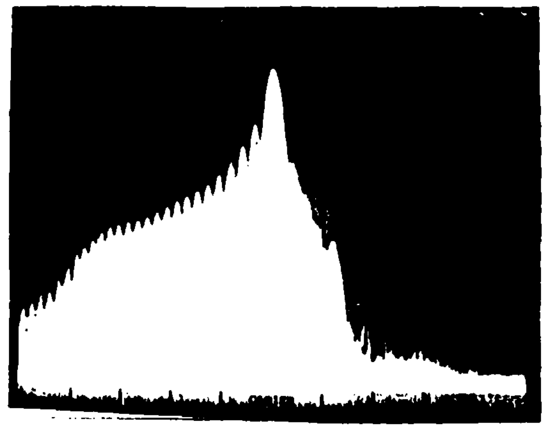


100 MHz/div. (30 minutes)



20 MHz/div. (30 minutes)

3700 MHz

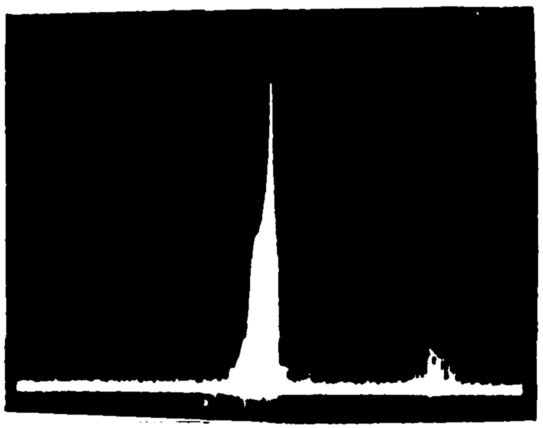


2 MHz/div. (30 minutes)

FIGURE 4.27

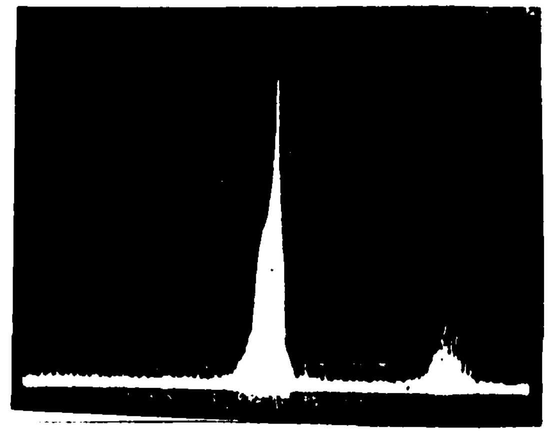
Standardized Coaxial Magnetron, VMS-1104, S/N 1007R, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001, V_f = 30 volts



V_f = 0 Volts

V_f = 30 Volts



V_f = 50 Volts

Vertical 10 dB/div.   Horizontal = 20 MHz/div.

3700 MHz

FIGURE 4.28

Standardized Coaxial Magnetron, VMS-1104, S/N 1007R, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001

4.5.2 S/N 1008

The VMS-1104 vacuum insert S/N 1008 was inserted into the "B" cavity and tested in the Varian test modulator. Table 4.9 provides operating data similar to that of Table 4.7 for insert S/N 1007R. Comparable rf performance was obtained; some increase in leading edge time jitter is apparent.

Figures 4.29 to 4.34 show both video data (detected rf pulse and current) and spectrum characteristics. In general, the spurious level is some -55 dB or better. Exceptions occur at 3550 MHz where a particular hybrid cavity mode is excited to the -50 dB level and at 3700 MHz where the TE_{121} mode approximates -50 dB (-46 to -48 dB). Figure 4.33 shows the level of the TE_{121} mode as the tube is tuned from 3660 MHz to 3700 MHz. The TE_{121} mode spurious was checked while operating the tube in a 1.5:1 mismatch, and these data are shown in Figure 4.34. The level of the TE_{121} mode spurious is -50 dB. Figure 4.35 provides the video data under these conditions.

The tube was reevaluated on March 18, 1981; data was found to be in good agreement with that of Table 4.9. The spurious level at 3700 MHz was checked. Figure 4.36 shows the TE_{121} mode level at initial turn on of the tube. After some five minutes the level has increased to some -50 dB. After 7 minutes the level decreased to a low level. Further evaluation showed the level to stabilize a about -52 dB as shown in Figure 4.37. Detailed photographs of the TE_{121} mode are shown in Figure 4.38 for current levels of 55 and 60 ma. The spurious level is -50 dB or better. In these latter tests

the spurious level appeared to be an improvement over that initially recorded. In general, the insert S/N 1008 operating in the "B" cavity satisfies the desired -50 dB spurious level.

TABLE 4.9

Test Results, Band IV Coaxial Magnetron, VMS-1104

S/N 1008, Cavity B

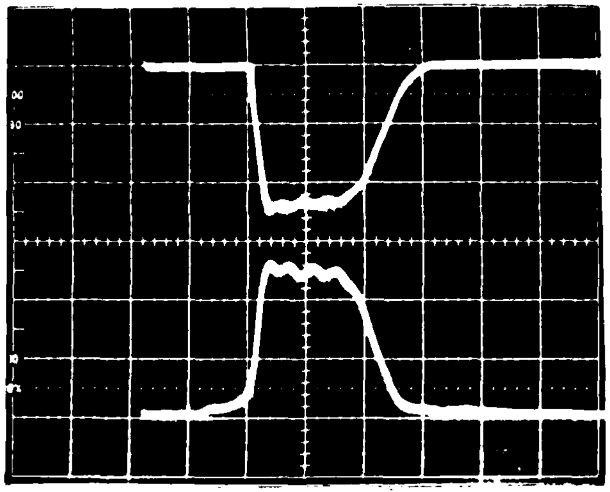
Test Modulator K-277: I_{avg} = 55 ma; tpc = 1.9 μs; duty = 0.001, V_f = 30 volts

Frequency (MHz)	Voltage (kv)	Power (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Missing Pulses (%)	Pulling (MHz)	Pushing (KHz/amp)	Leading Edge Jitter (ns)	
								(1)	(2)
3500	36.5	1060	0.6	10	0.0	1.0	10	3.5	3.9
3550	37.0	1080	0.6	10	0.0	1.1	8	5.8	7.3
3600	37.5	1170	0.65	10	0.0	1.4	6	3.0	3.9
3650	37.8	1180	0.65	10	0.0	1.6	2	5.1	5.8
3700	38.0	1070	0.6	10	0.0	1.2	14	4.9	6.8

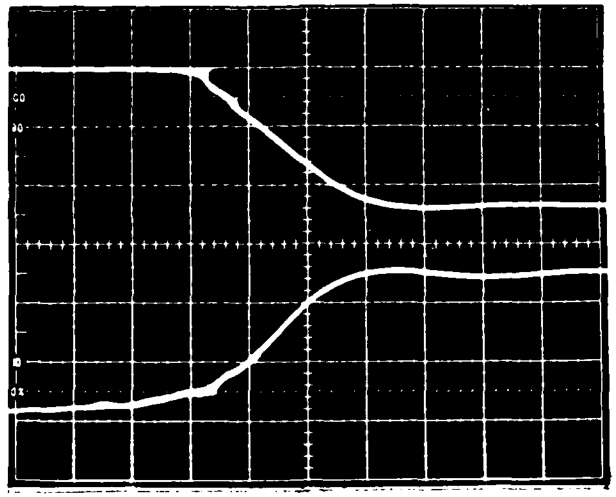
(1) Matched Load

(2) 1.5 VSWR, Worst Phase

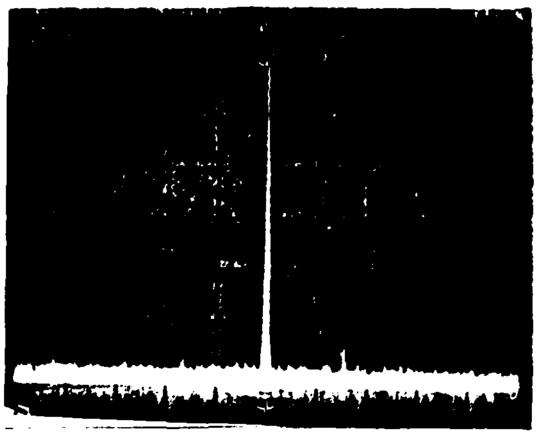
March 16, 1981



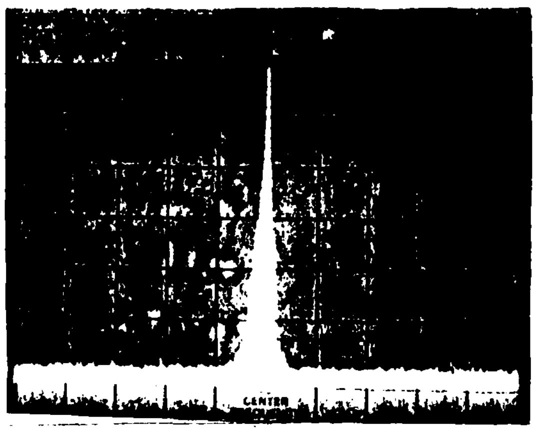
1.0 μs/div.
Top Trace: Detected RF Pulse



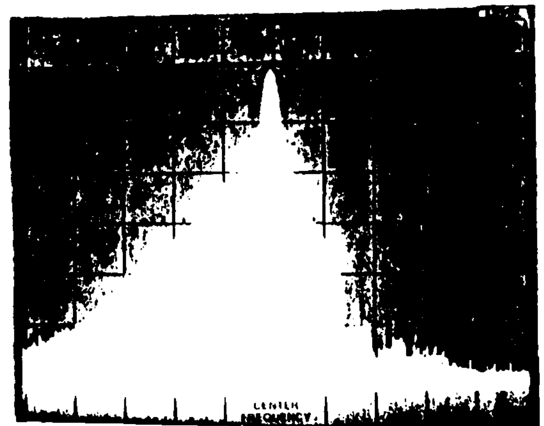
0.1 μs/div.
Bottom Trace: Current Pulse (vert. 20 A/div.)



100 MHz/div.



20 MHz/div.



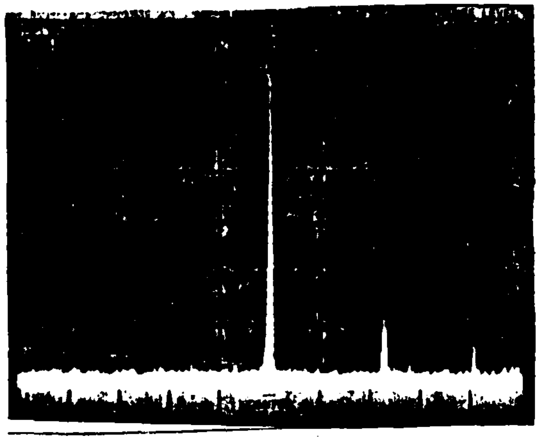
2 MHz/div.

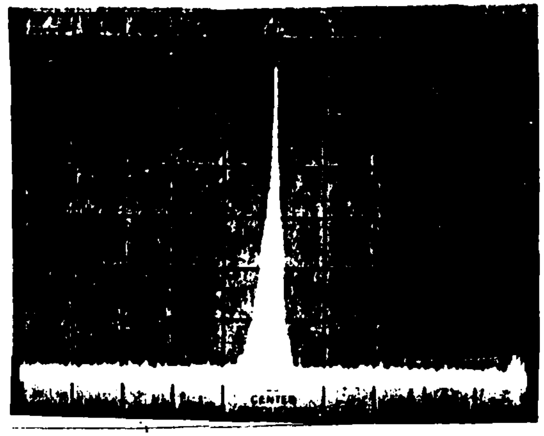
Vertical = 10 dB/div. 3500 MHz

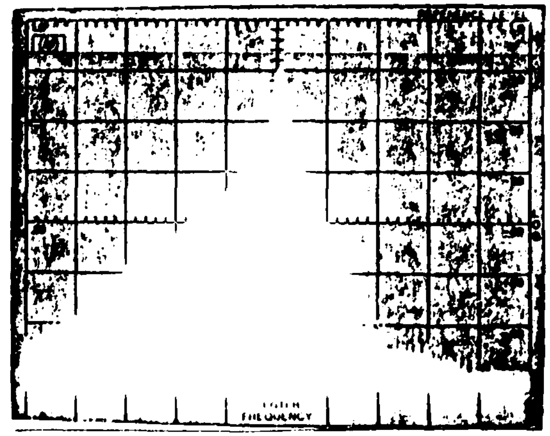
FIGURE 4.29

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; t_{pc} = 1.9 μs; Duty = 0.001; V_f = 30 volts







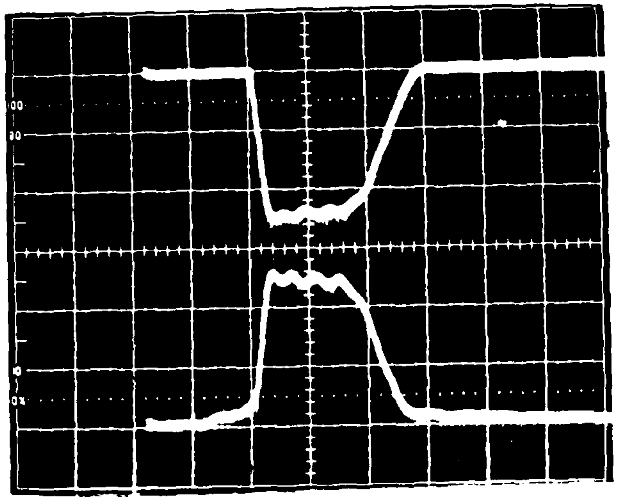
100 MHz/div. 20 MHz/div. 2 MHz/div.

Vertical = 10 db/div. 3550 MHz

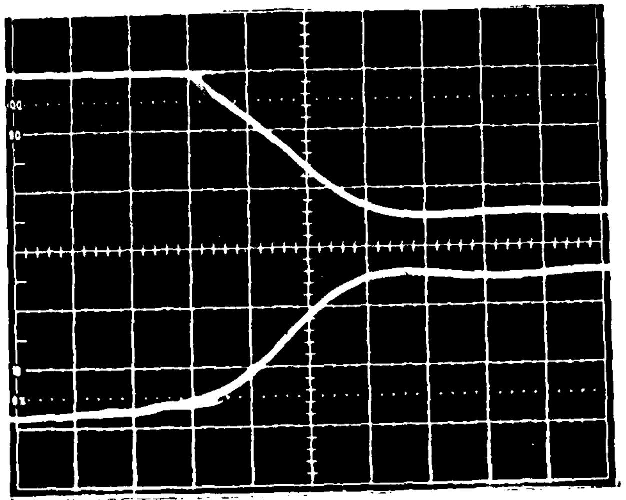
FIGURE 4.30

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts

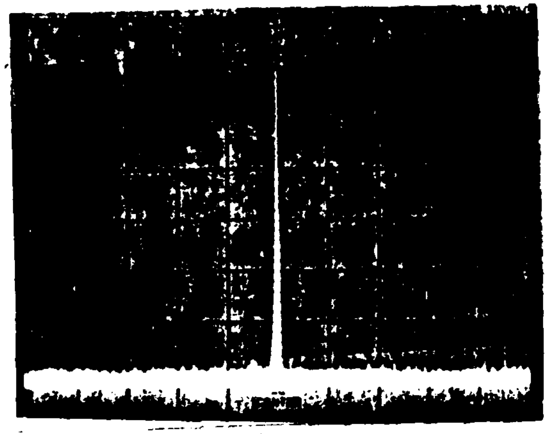


1.0 μs/div.

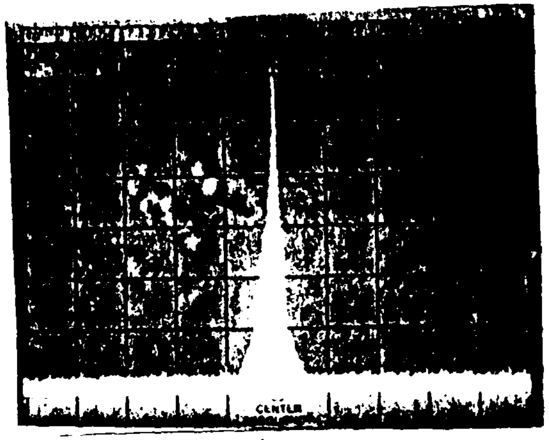


0.1 μs/div.

Top Trace: Detected Rf Current   Bottom Trace: Current Pulse (vert. 20 A/div)



100 MHz/div.



20 MHz/div.

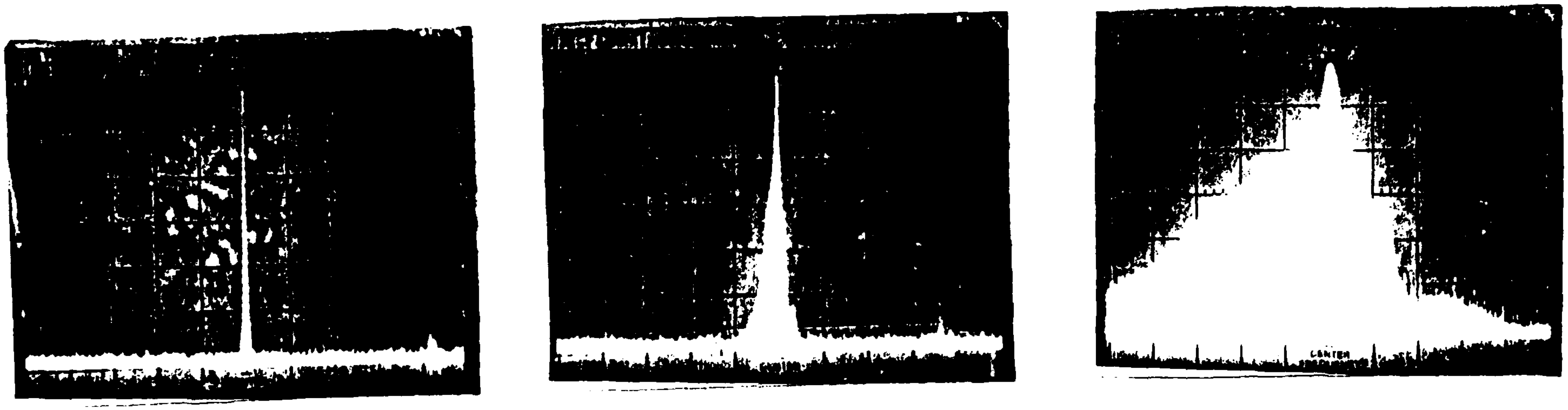
2 MHz/div.

Vertical = 10 dB/div.   3600 MHz

FIGURE 4.31

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts



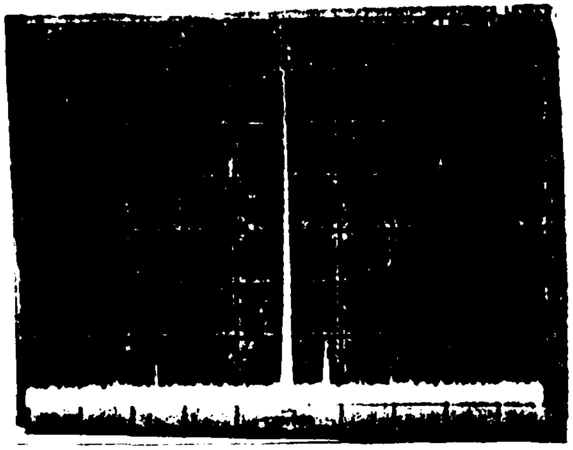
100 MHz/div.   20 MHz/div.   2 MHz/div.

Vertical = 10 dB/div.   3650 MHz

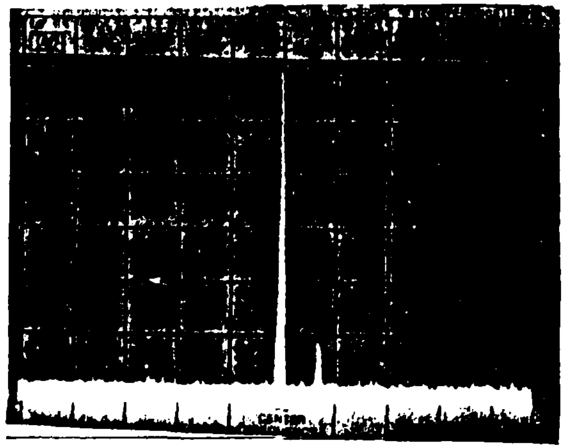
FIGURE 4.32

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

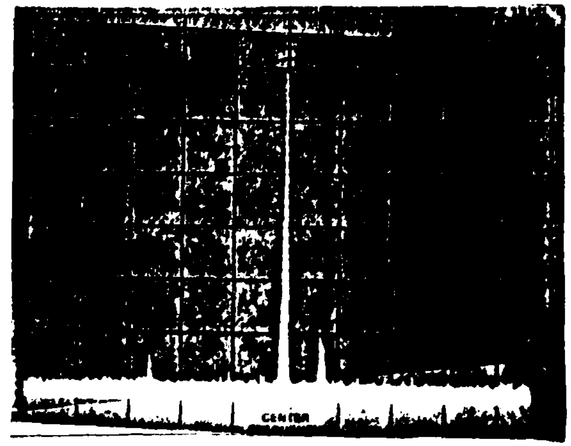
I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts



3660 MHz

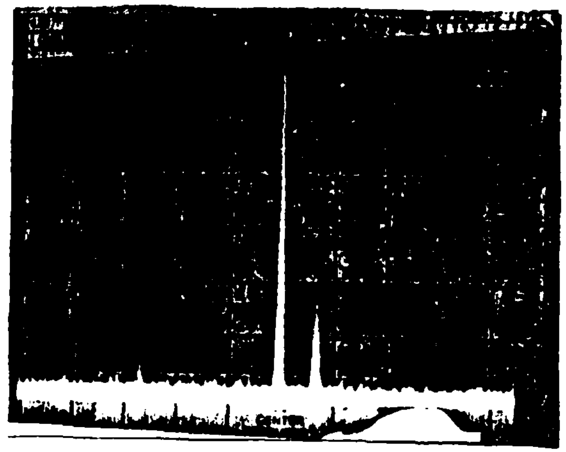


3670 MHz



3680 MHz

3690 MHz



3700 MHz

Vertical = 10 dB/div.

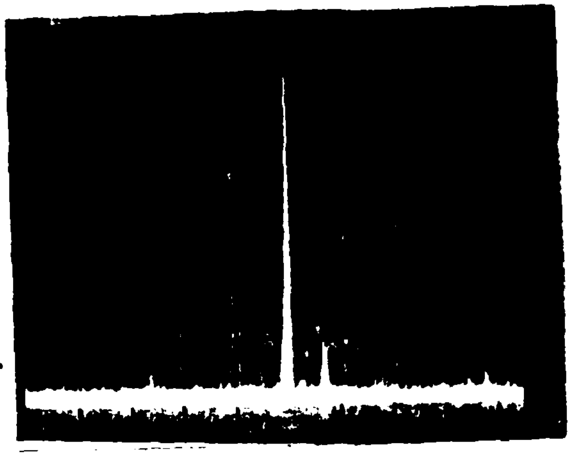
Horizontal = 100 MHz/div.

FIGURE 4.33

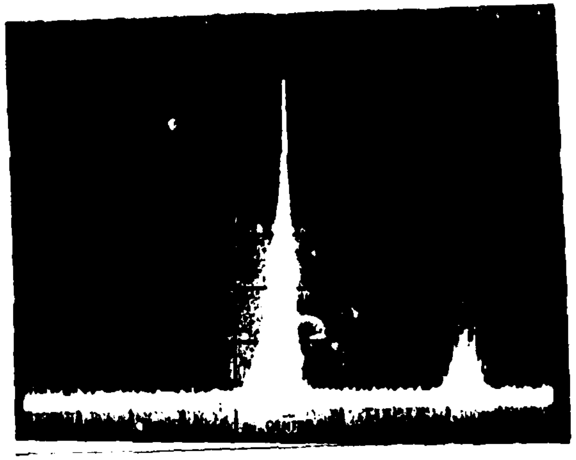
Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 us; Duty = 0.001; V_f = 30 volts

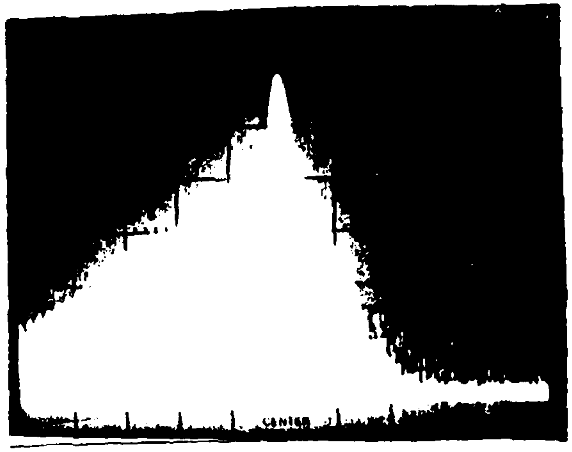
3/16/81



100 MHz/div.



20 MHz/div.



2 MHz/div.

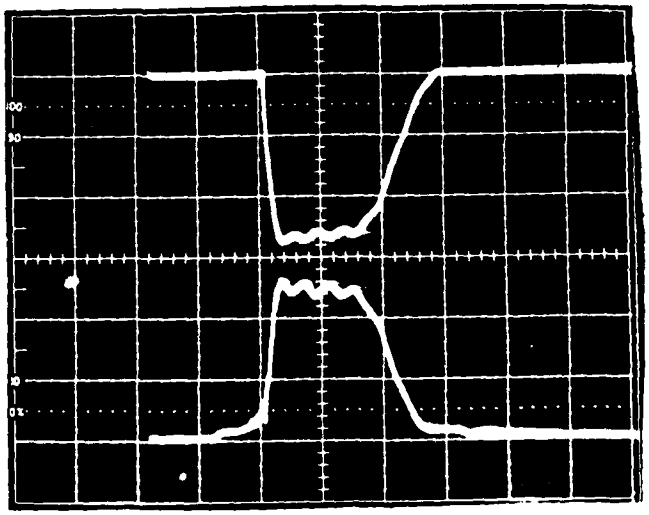
Vertical = 10 dB/div. 3700 MHz 1.5:1 VSWR at Worst PHase

FIGURE 4.34

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts

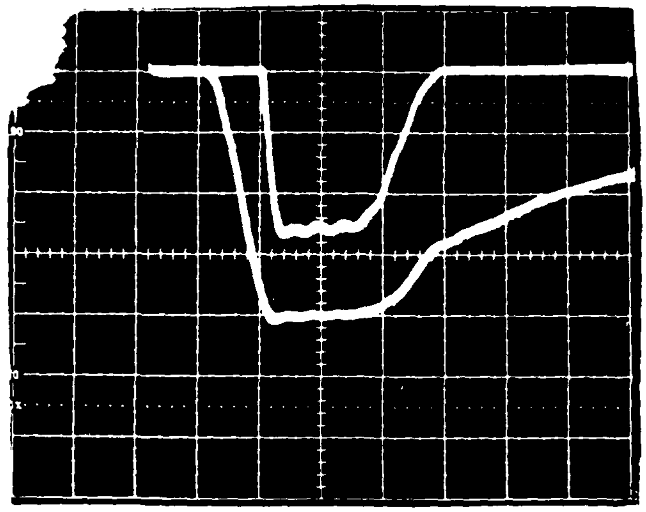
3/16/81



1 µs/div.

Top Trace: Detected RF Pulse

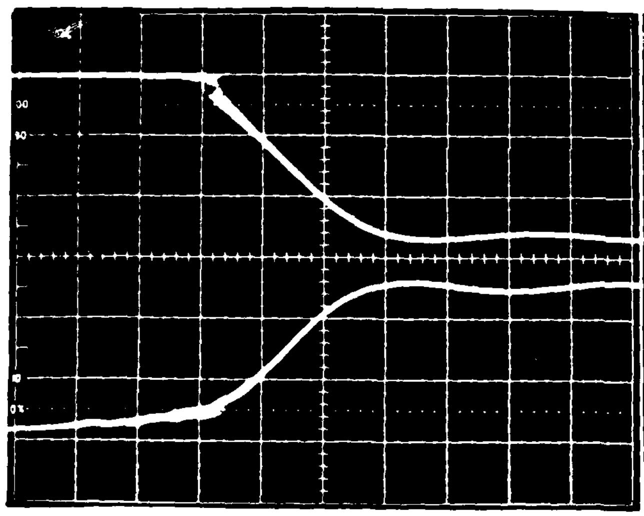
Bottom: Current Pulse (vert. 20 a/div.)



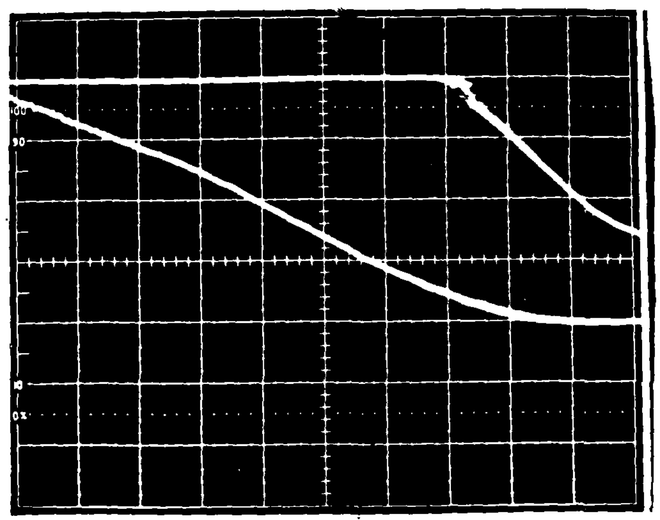
1 µs/div.

Top Trace: Detected RF Pulse

Bottom: Voltage Pulse (vert. 10 KV/div.)



0.1 µs/div.



0.1 µs/div.

Expanded Scale

3700 MHz

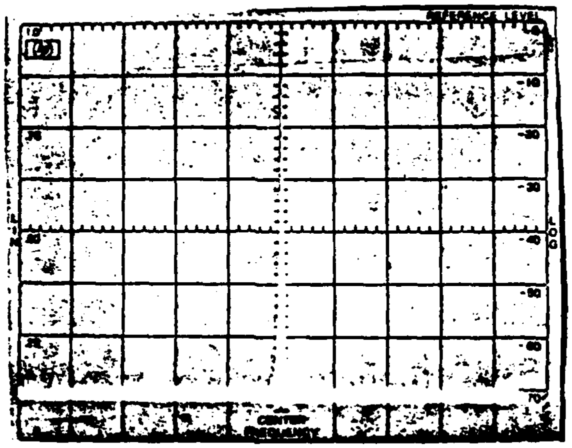
1.5:1 VSWR at Worst PHase

FIGURE 4.35

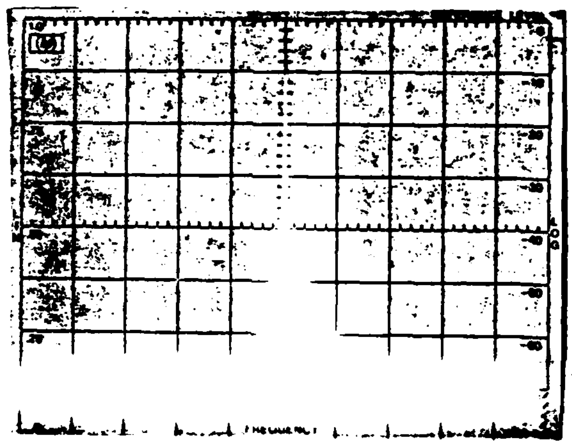
Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 µs; Duty = 0.001; V_f = 30 volts

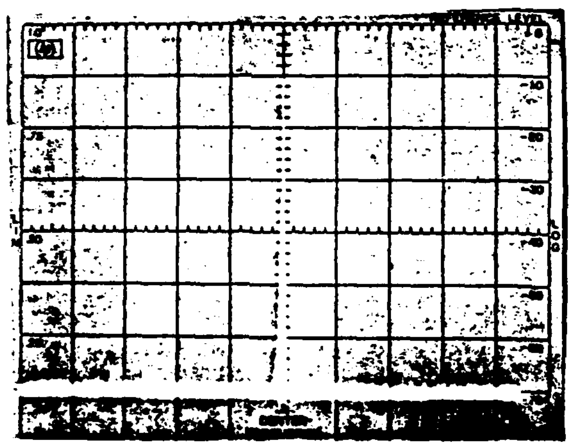
3/16/81



Turn On



5 Minutes



7 Minutes

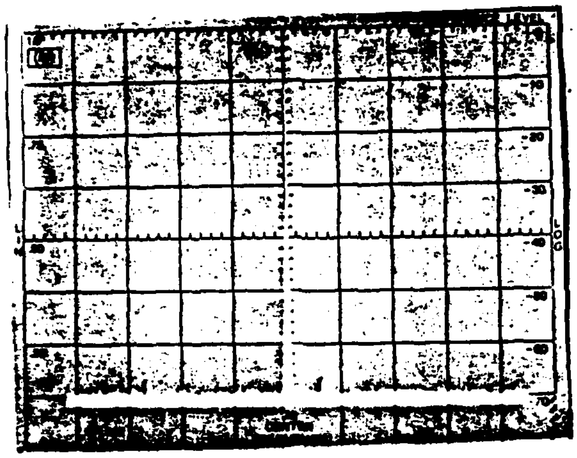
Vertical = 10 dB/div. 100 MHz/div. 3700 MHz

FIGURE 4.36

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

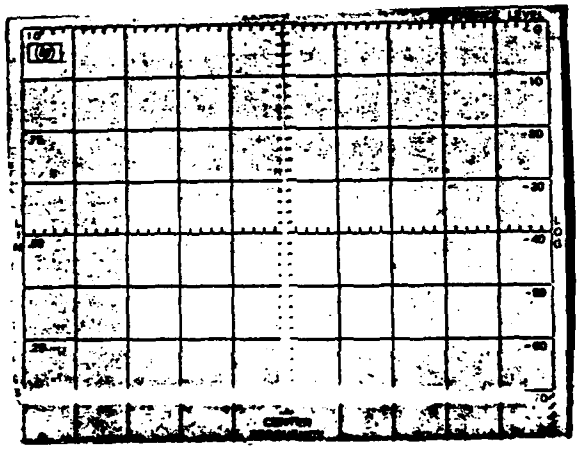
I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts

3/18/81



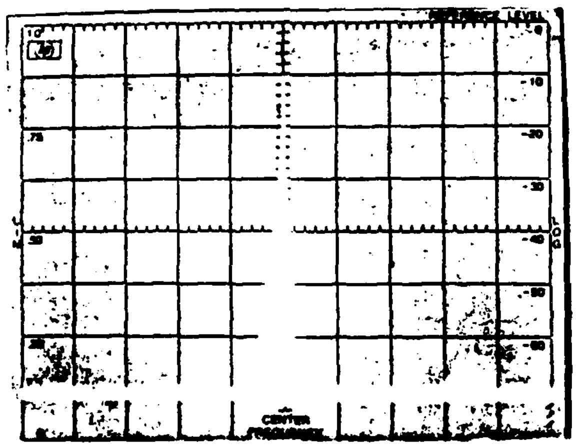
20 Minutes

100 MHz/div.



90 Minutes

100 MHz/div.



90 Minutes

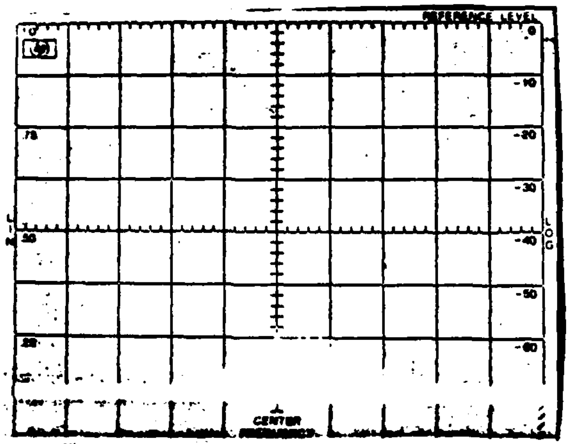
20 MHz/div.

Vertical = 10 dB/div. 3700 MHz

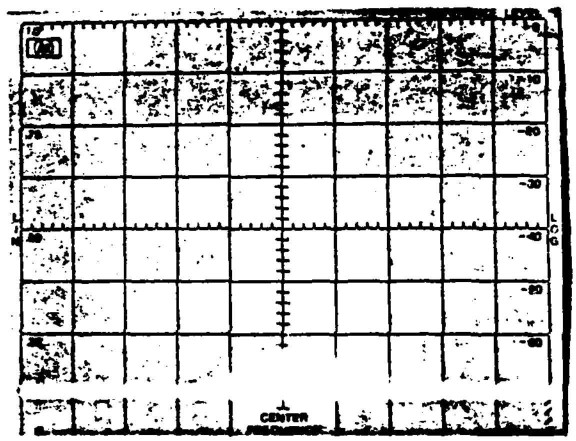
FIGURE 4.37

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts



5 MHz/div. I_{avg} = 60 ma



5 MHz/div. I_{avg} = 55 ma

Vertical = 10 dB/div. 3700 MHz

FIGURE 4.38

Standardized Coaxial Magnetron, VMS-1104, S/N 1008, Cavity B, Test Modulator K-277

I_{avg} = 55 ma; tpc = 1.9 μs; Duty = 0.001; V_f = 30 volts

4.6 Test of Band IV Tube, VMS-1104, S/N 1007R and S/N 1008 with SPN-43 Modulator

The vacuum inserts S/N 1007R and S/N 1008 were tested in the "B" cavity using the SPN-43 modulator at Varian/Beverly on April 15-16, 1981. Measurements on the "B" cavity were completed on April 17, 1981.

The VMS-1104 coaxial magnetron was operated external to the SPN-43 cabinet under pulse conditions consistent with a duty cycle of 0.00086. Modulator components consistent with those installed at NESEA were employed. Some pulse shape variation could be expected due to the inductance and capacitance of the long high voltage lead employed; pulse width was measured at 0.95 microsecond.

4.6.1 S/N 1007R

Table 4.10 provides a listing of the data taken on vacuum insert S/N 1007R operating in a matched load condition corresponding to operation into the SPN waveguide run with waveguide isolator (VSWR some 1.11 at 3700 MHz, 1.13 at 3600 MHz, and 1.2 at 3500 MHz). The data indicates satisfactory performance over 3500-3700 MHz.*

The spectrum and rf pulse characteristics were photographs and are presented in Figures 4.39-4.42.* The spectrum photos show broadband spurious better than -55 dB; spectrum width is some 10 MHz at -40 dB level. The detected rf pulse is shown for a horizontal display of 0.5 and 0.05 microsecond per division. Good leading edge stability of the pulse is apparent.

---

*These data and photographs should be compared to those of S/N 1005 recorded at Varian and at NESEA (see Section 4.2 and 4.4).

For reference the voltage and current pulse shapes are presented in Figure 4.43. In addition, we provide a photo, Figure 4.44b of the voltage pulse expanded for voltage rate-of-rise comparison, and a detailed exposure, Figure 4.44b of the close in spectrum at 3700 MHz to inspect the TE_{121} mode spurious level. This detailed exposure indicates the level is some -55 dB and represents very acceptable performance.

The insert-cavity combination was also evaluated for missing pulse stability when operated into a 1.5:1 VSWR mismatch set for worst phase condition. The tube showed good stability except at lower frequency extremity of the tuning range at 3500 MHz. Approximately one percent missing pulse stability was recorded in comparison to a desired maximum of some 0.25%. Due to the essentially matched load conditions existing in the SPN equipment, it is expected that stability will not be a problem if the tube is tuned to this presently out-of-band frequency.

A copy of the test data taken on S/N 1007R is included as Table 4.11.

4.6.2 S/N 1008

The vacuum insert S/N 1007R was next replaced by insert S/N 1008, and the tests described above repeated. Table 4.12 lists the recorded data for S/N 1008 operating in the "B" cavity. Performance and matched load stability for this insert-cavity combination is satisfactory over the frequency range of 3500-3700 MHz.

Spectrum and video photographs are given in Figures 4.45 to 4.49. This insert shows some tendency to generate spurious at

approximately 4000 MHz. The level of this spurious is -50 dB or better. The insert also shows some TE_{121} mode spurious generation at 3700 MHz; the detailed exposure photo of Figure 4.50 shows this spurious to be -50 dB. The above spurious levels are at or below the previously established acceptable spurious level for this tube.

Operation of the insert-cavity combination into the worst phase-mismatch condition showed a high missing pulse count at 3550 MHz estimated at one to two percent. Due to the matched load conditions in the SPN-43 transmitter it is expected the tube will exhibit acceptable stability if tuned to this presently out-of-band frequency.

The above tests were performed at a nominal heater level of 40 volts. If the cathode emission is adequate it is possible to operate these magnetrons at zero heater level with generally improved stability. The past history of this type of operation is documented in the various quarterly reports of the standardized coaxial magnetron programs.

Consequently, the heater level was reduced to zero and the stability remeasured. These values are given in Table 4.13 for both matched load and mismatch load conditions.

Note the stability in each case is excellent. The spectrum was checked under zero heater conditions and, as expected, some frequencies previously well suppressed at the higher heater level were excited. The spectrum photos of Figure 4.51 show the spurious level to still be at or below the desired -50 dB level.

A copy of the test data taken on S/N 1008 is included as Table 4.14 and Table 4.15.

Additional insert and cavity performance data were taken to complete the characterization of the insert-cavity combination:

a. anode-cathode capacitance

b. tuning data

c. tuner torque

d. backlash

e. mechanical stop limits

These data are listed in Table 4.16.

TABLE 4.10

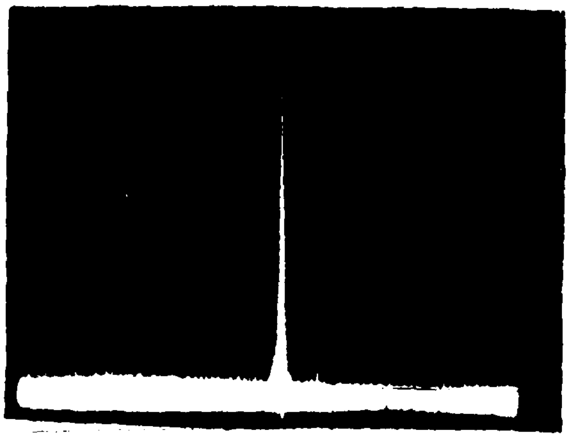
Test Results, Band IV Coaxial Magnetron, VMS-1104, S/N 1007R,

Cavity B, Operating with SPN-43 Modulator

Test Date: April 15, 1981

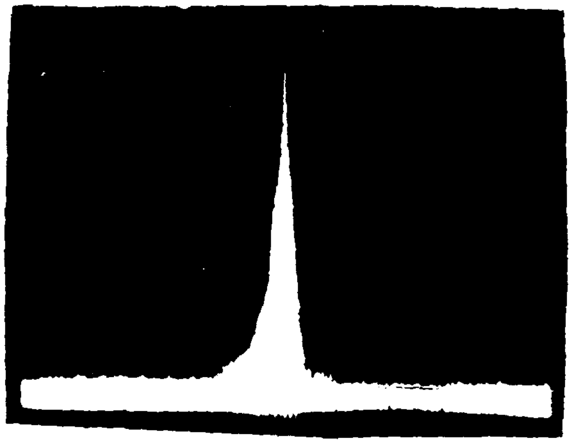
Test Conditions: Pulse Width = 0.95 μs; Duty Cycle = 0.00086; Heater Voltage = 55 Volts; Current (avg.) = 40 ma

Frequency (MHz)	Power (Avg.) (watts)	Power (Peak) (kilowatts)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Stability (%)	Jitter (ns)	Pushing KHz/A
3500	730	849	1.15	-10.5	0.17	4.0	23.0
3550	770	895	1.10	-11.0	0.03	4.0	22.0
3600	800	930	1.10	-10.0	0.00	3.0	20.0
3650	770	895	1.10	-10.0	0.00	3.0	19.0
3700	720	837	1.20	-10.0	0.00	2.0	16.0



100 MHz/Div.

Center Frequency = 3700 MHz



20 MHz/Div.

2 MHz/Div.

Vertical 10 dB/Div., 300 KHz Resolution BW, 2 Sec. Sweep ...

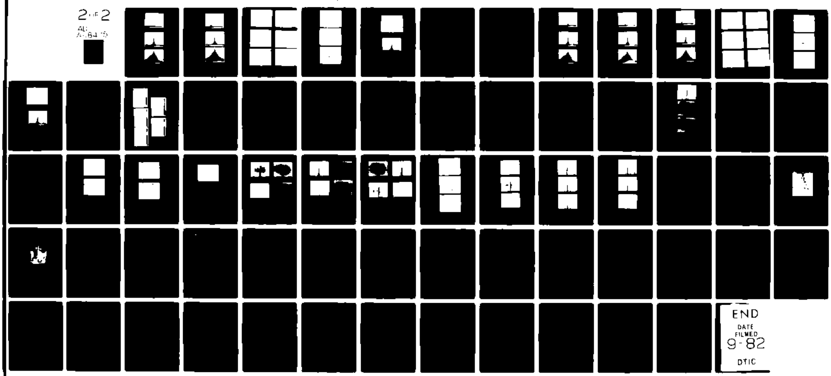
FIGURE 4.39

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-...

I_b = 40 ma; F_o = 3700 MHz

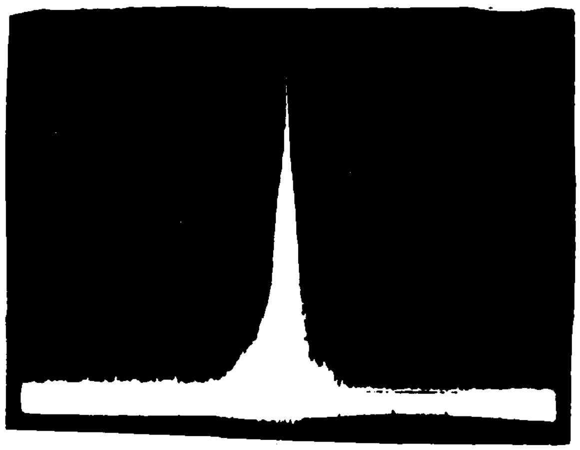
AD-A118 475 VARIAN ASSOCIATES INC BEVERLY MA BEVERLY DIV F/G 9/1
CONSTRUCTION, TEST AND DELIVERY OF STANDARDIZED COAXIAL MAGNETR--ETC(U)
SEP 81 T E RUDEN N66001-79-C-0225

UNCLASSIFIED NOSC-CR-112 NL

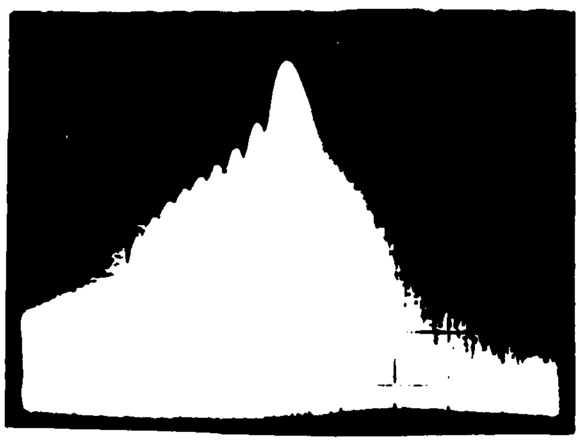


100 MHz/Div.

Center Frequency = 3700 MHz



20 MHz/Div.



2 MHz/Div.

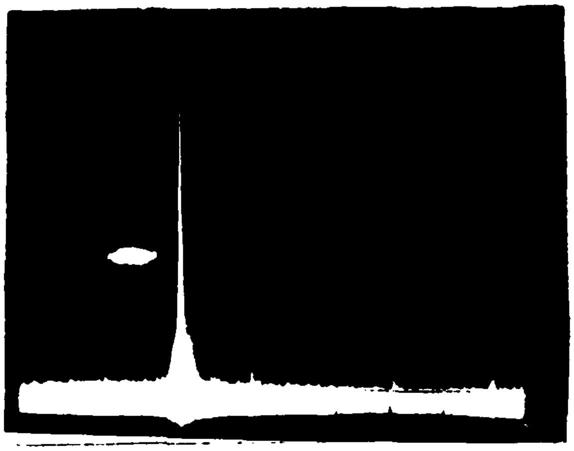
Veritcal 10 dB/Div., 300 KHz Resolution BW, 2 Sec. Sweep/Div.

FIGURE 4.40

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-43 Varian

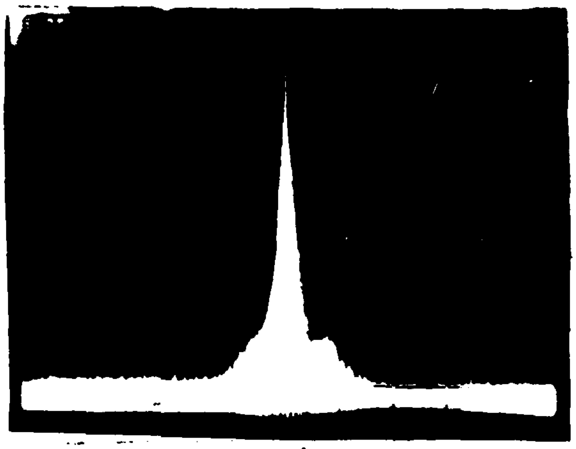
I_b = 40 ma; F_o = 3600

April 15, 1981

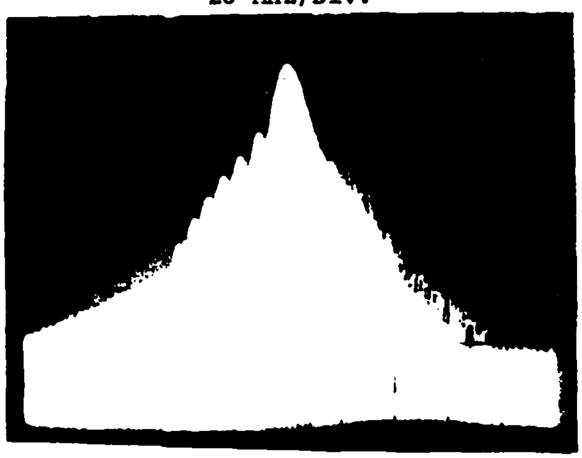


100 MHz/Div.

Center Frequency = 3700 MHz



20 MHz/Div.



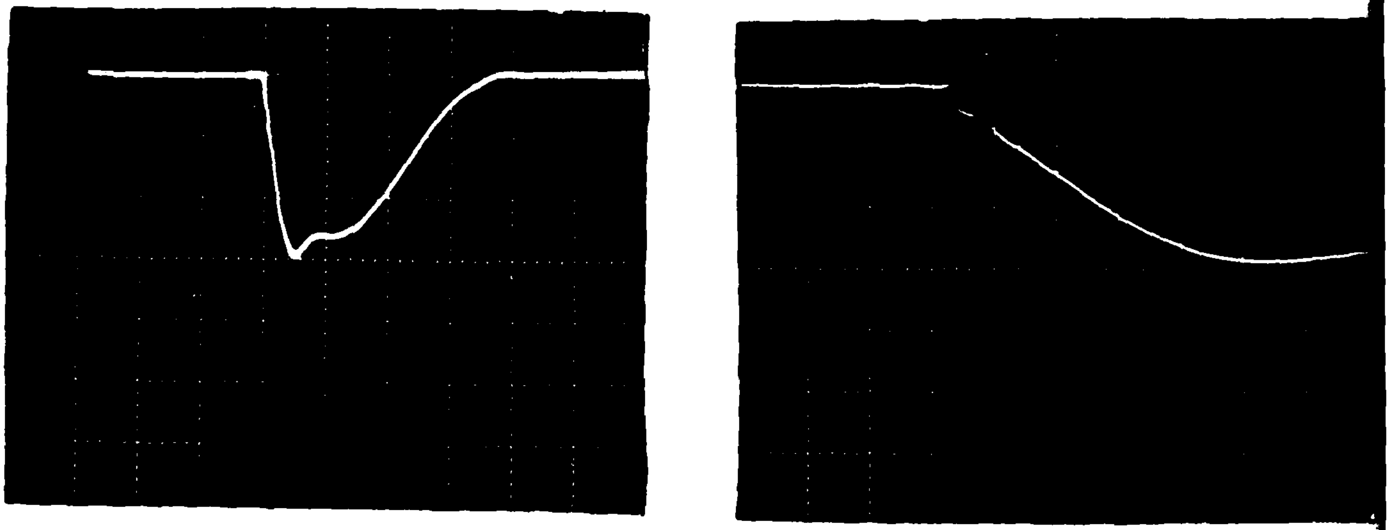
2 MHz/Div.

Vertical 10 dB/Div., 300 KHz Resolution BW, 2 Sec. Sweep/Div.

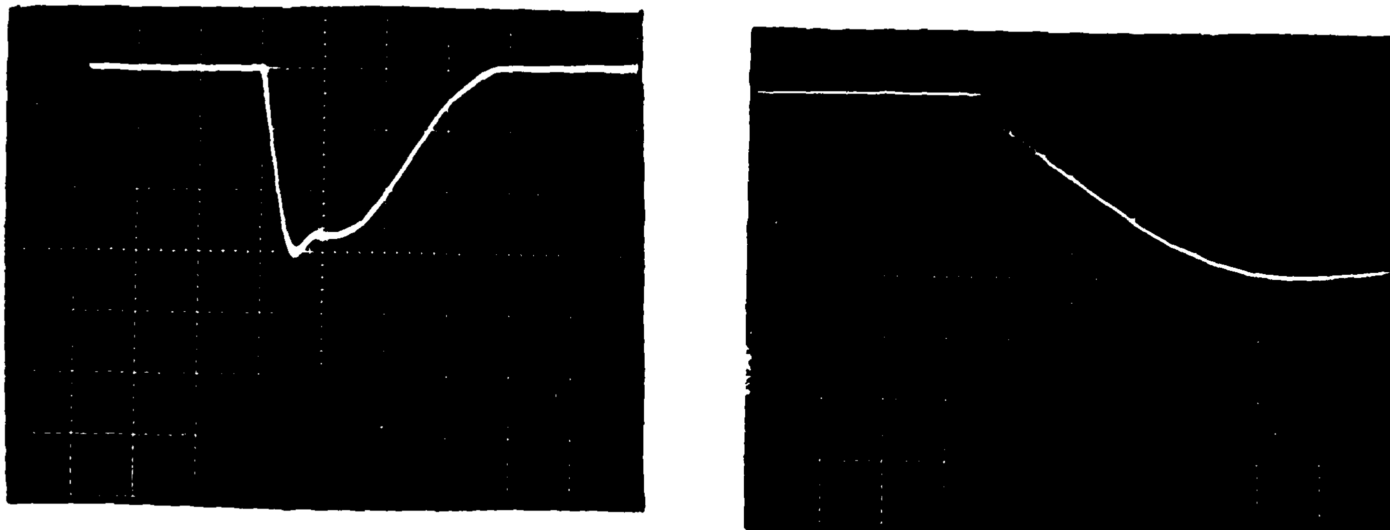
FIGURE 4.41

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-43 Varian

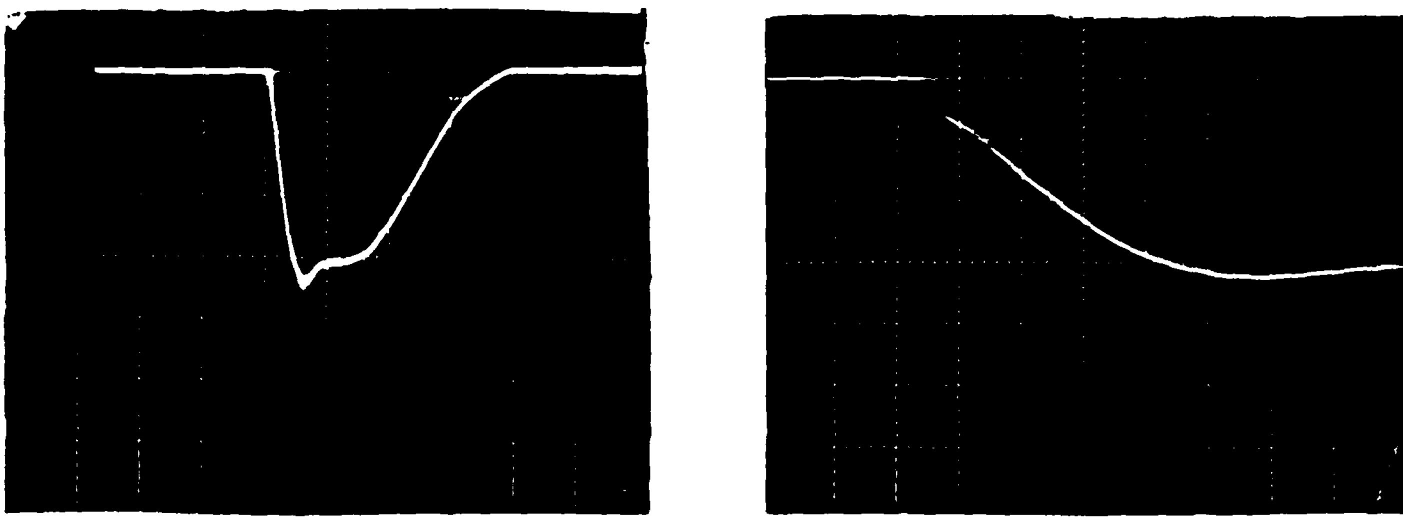
I_b = 40 ma; F_o = 3500 MHz



3700 MHz



3600 MHz



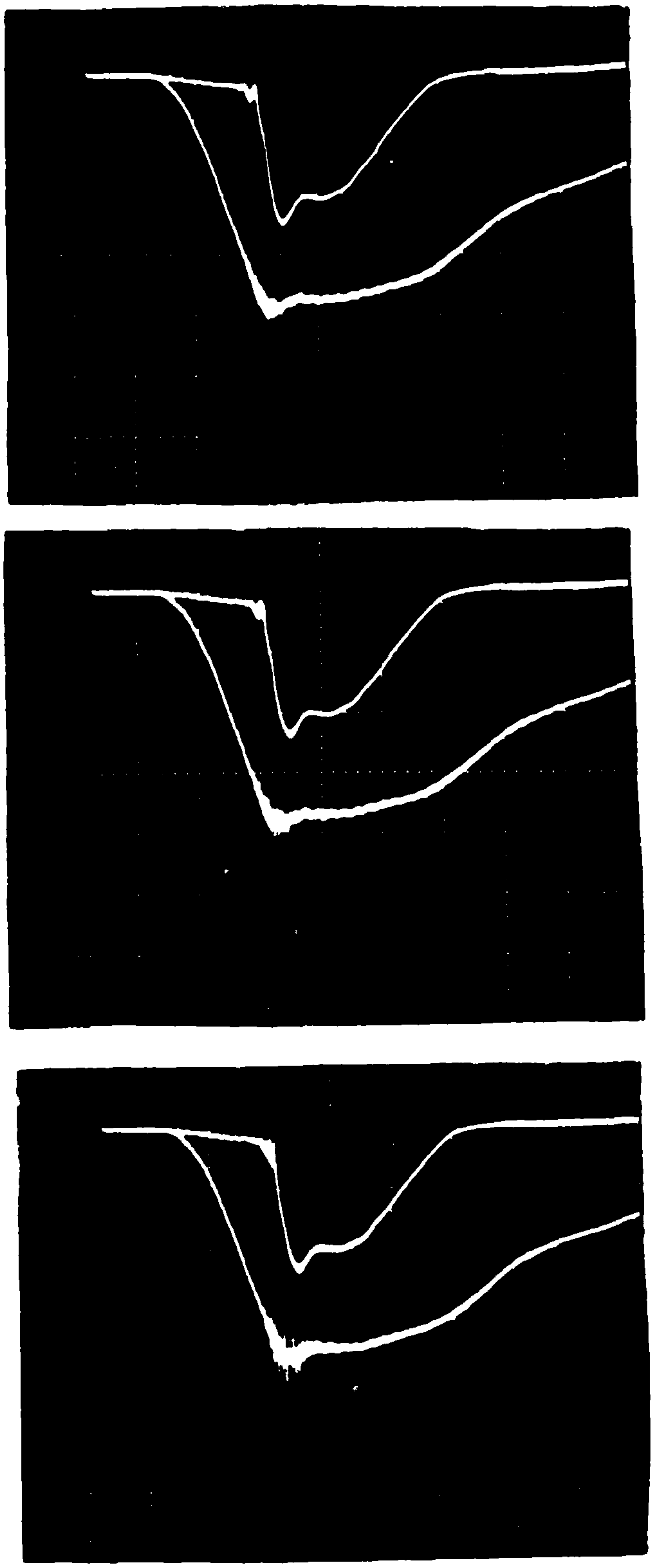
0.5 μs/div. 3500 MHz 0.05 μs/div.

FIGURE 4.42

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-43 Varian

I_b = 40 ma

April 15, 1981



Horizontal = 0.5 μs/div.
Voltage 10 KV/div.
Current 20 A/div.

3700 MHz

3600 MHz

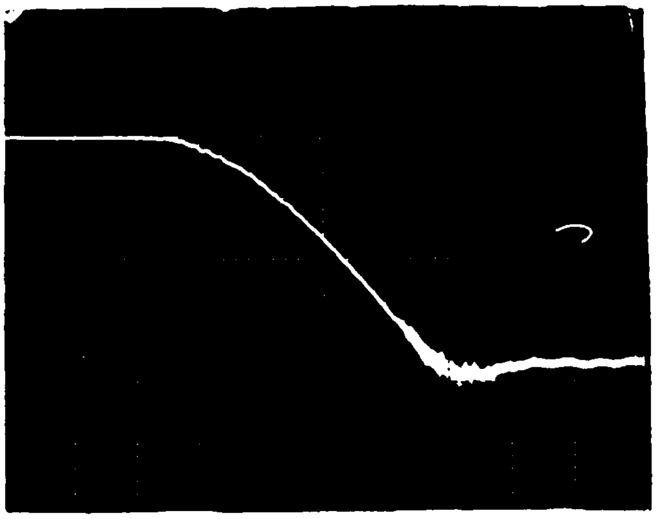
3500 MHz

FIGURE 4.43

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-43 Varian

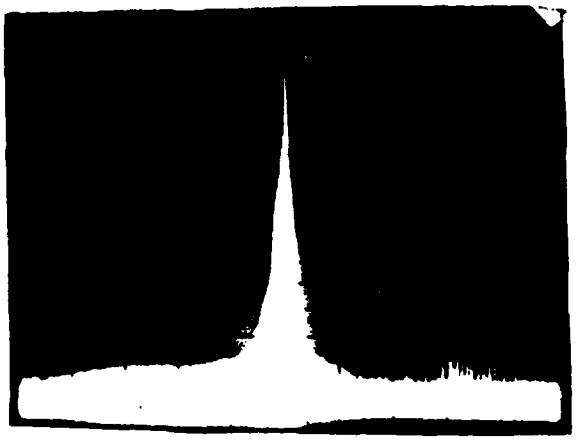
I_b = 40 ma

April 15, 1981



(a) Voltage Horizontal = 0.2 μs/div.

Vertical = 10 KV/div.



20 MHz/div.

Vertical 10 dB/div., 5 Sec. Sweep/Div.

(b) Spectrum

FIGURE 4.44

VMS-1104 Coaxial Magnetron, S/N 1007R, AN/SPN-43 Varian

I_b = 40 ma, F_o = 3700 MHz

April 15, 1981

TABLE 4.11

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1007R

CAVITY B, OPERATING WITH SPN-43 MODULATOR

Test Date: April 15, 1981

Test Conditions: Pulse Width = 0.95 μs; Duty Cycle = 0.00086; Heater Voltage = 55 Volts; Current (avg.) = 40 ma

Frequency (MHz)	Power (avg.) (watts) (1)	Power (Peak) (kw) (1)	Bandwidth (MHz) (2)	Side Lobe Ratio (dB) (2)	Stability (%) (1)	Stability (%) (2)	Jitter (ns) (1)	Pushing (KHz/A) (1)
3500	730	849	1.15	10.5	0.17	0.94	4.0	16
3550	770	895	1.10	11.0	0.03	--	4.0	19
3600	800	930	1.10	10.0	0.00	0.00	3.0	20
3650	770	895	1.10	10.0	0.03	--	3.0	22
3700	720	837	1.12	10.0	0.00	0.00	2.0	23

(1) Matched Load

(2) 1.5:1 VSWR, Worst Phase

TABLE 4.12

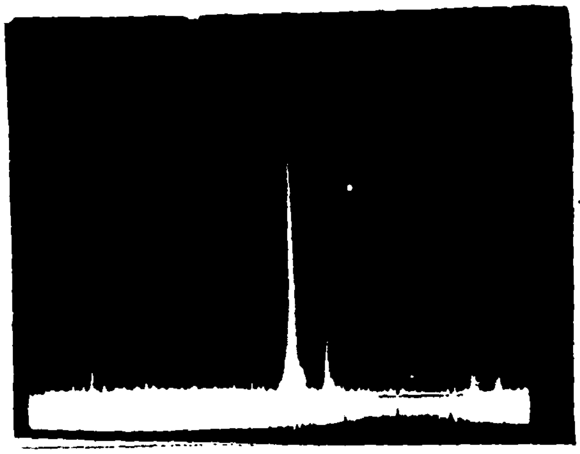
Test Results, Band IV Coaxial Magnetron, VMS-1104, S/N 1008

Cavity B, Operating with SPN-43 Modulator

Test Date: April 16, 1981

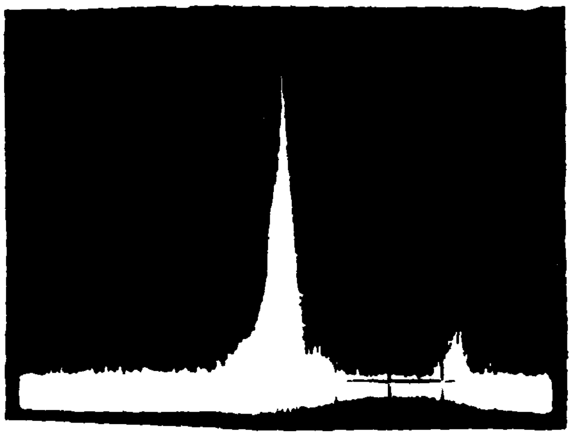
Test Conditions: Pulse Width = 0.95 μs; Duty Cycle = 0.00086; Heater Voltage = 40 Volts; Current (Avg.) = 40 ma

Frequency (MHz)	Power (Avg.) (watts)	Power (Peak) (kilowatts)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Stability (%)	Jitter (ns)	Pushing (KHz/A)
3500	740	860	1.20	-10.5	0.01	3.0	22.0
3550	770	895	1.20	-10.0	0.19	3.0	20.0
3600	780	907	1.20	-10.0	0.06	3.0	21.0
3650	750	872	1.20	-10.0	0.00	4.0	21.0
3700	690	802	1.15	-10.0	0.00	3.0	17.0

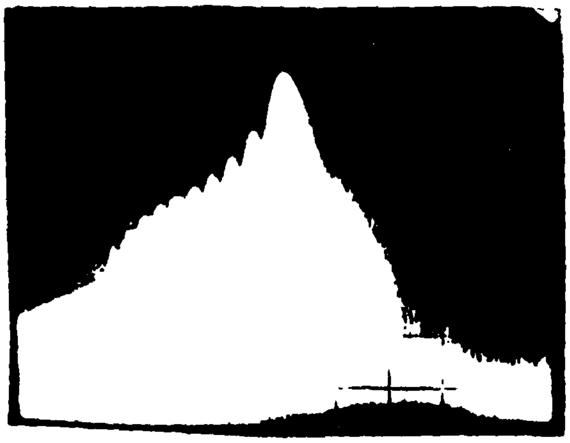


100 MHz/div.

Center Frequency = 3700 MHz



20 MHz/div.



2 MHz/div.

Vertical 10 dB/div., 300 KHz Resolution BW, 2 Sec. Sweep/div.

FIGURE 4.45

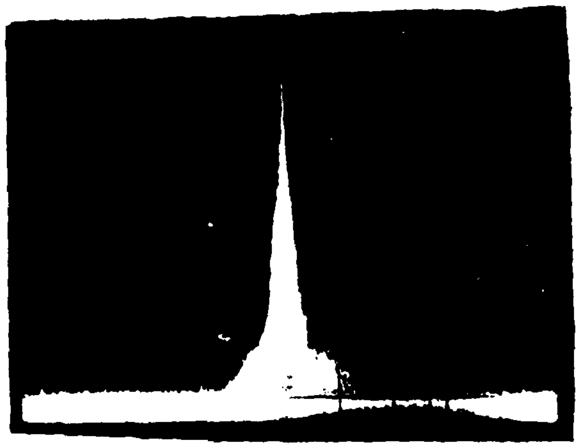
VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

I_b = 40 ma; F_o = 3700 MHz

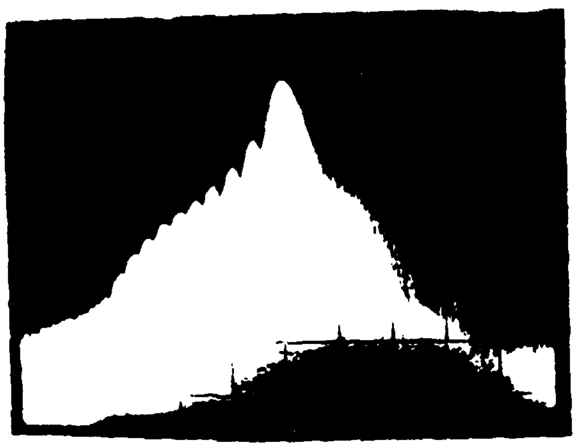
April 16, 1981

100 MHz/div.

Center Frequency = 3700 MHz



20 MHz/div.



2 MHz/div.

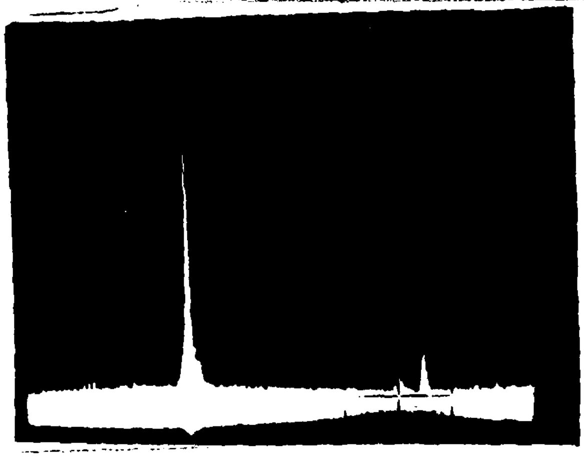
Vertical 10 dB/div., 300 KHz Resolution BW; 2 Sec. Sweep/div.

FIGURE 4.46

VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

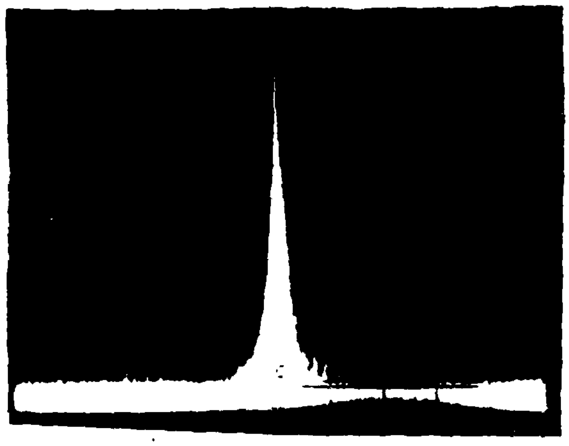
I_b = 40 ma; F_o = 3600 MHz

April 16, 1981

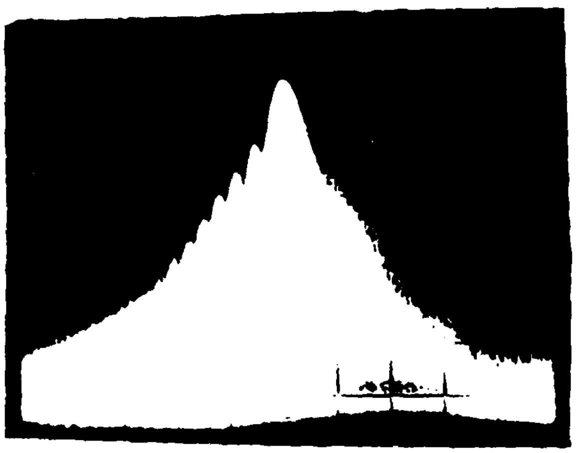


100 MHz/div.

Center Frequency = 3700 MHz



20 MHz/div.



2 MHz/div.

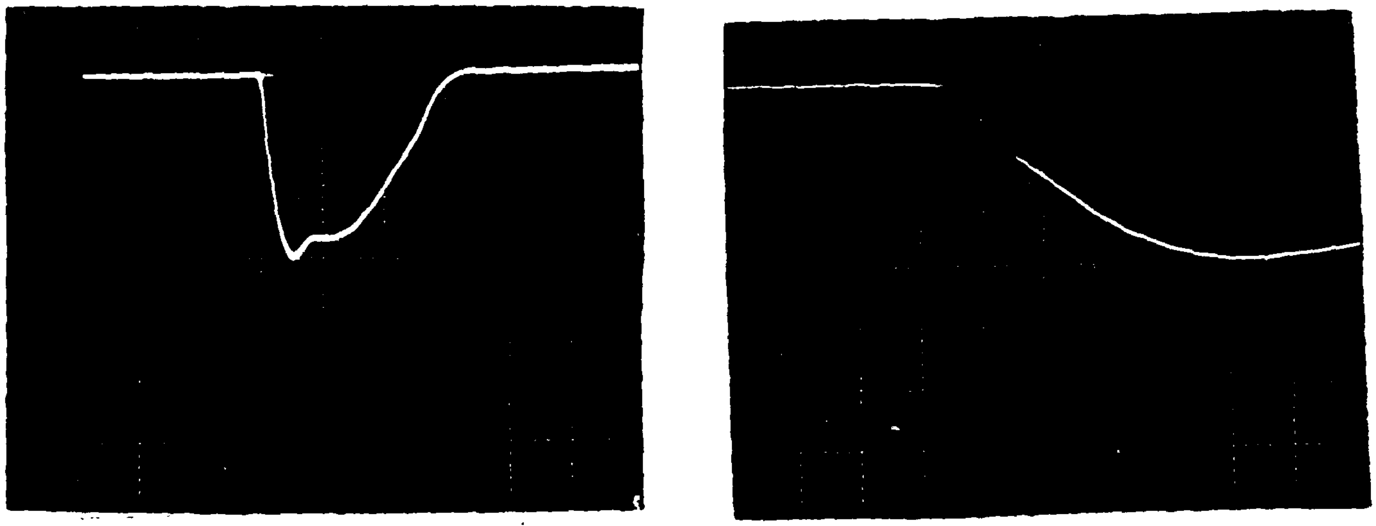
Vertical = 10 dB/div., 300 KHz Resolution BW, 2 Sec. Sweep/div.

<u>FIGURE</u> <u>4.47</u>

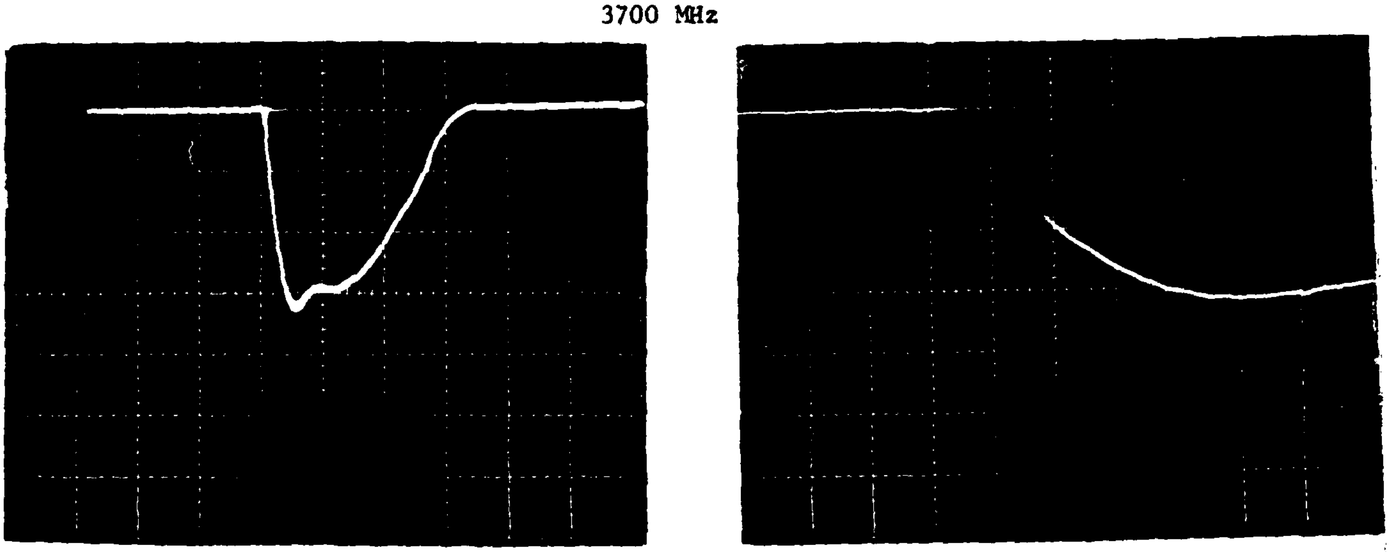
<u>VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian</u>

I_b = 40 ma; F_o = 3500 MHz

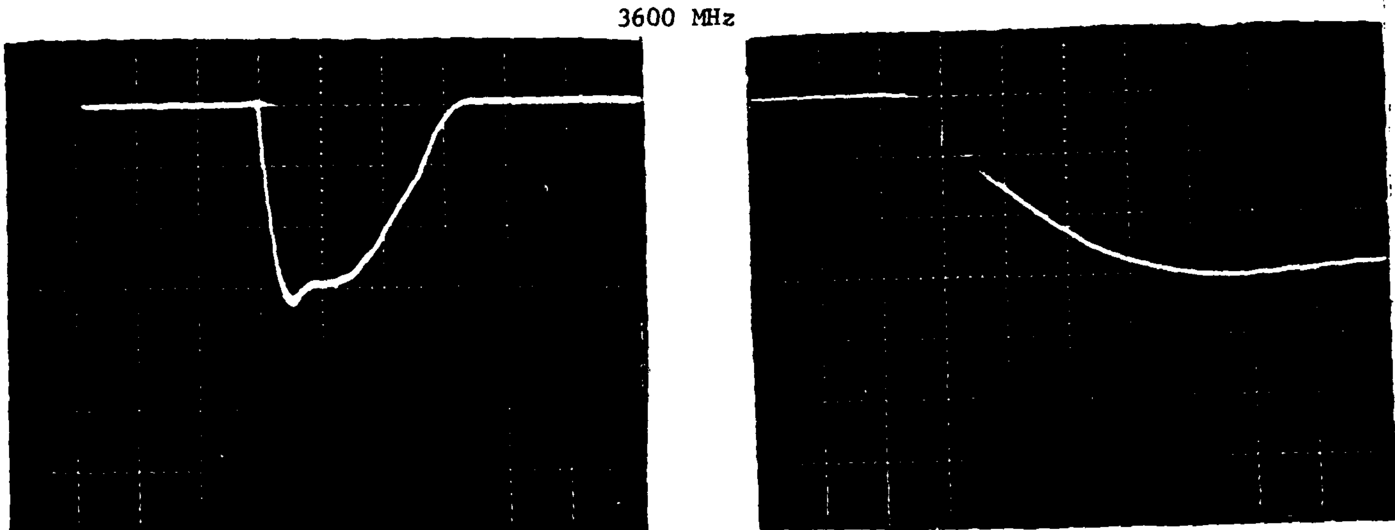
April 16, 1981



3700 MHz



3600 MHz



0.5 μs/div. 3500 MHz 0.05 μs/div.

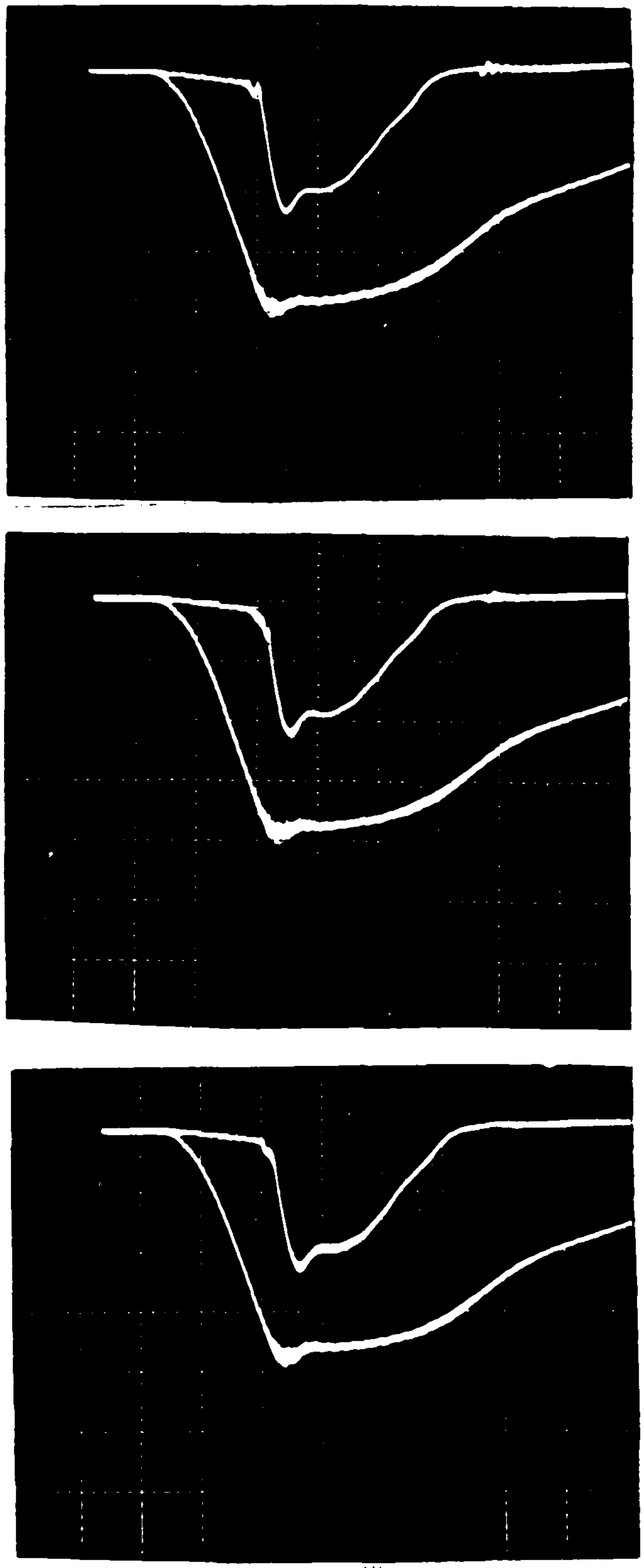
FIGURE 4.48

VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

$I_b = 40$ ma

April 16, 1981

Horizontal = 0.5 μs/div.
Voltage 10 KV/div.
Current = 20 A/div.



3700 MHz

3600 MHz

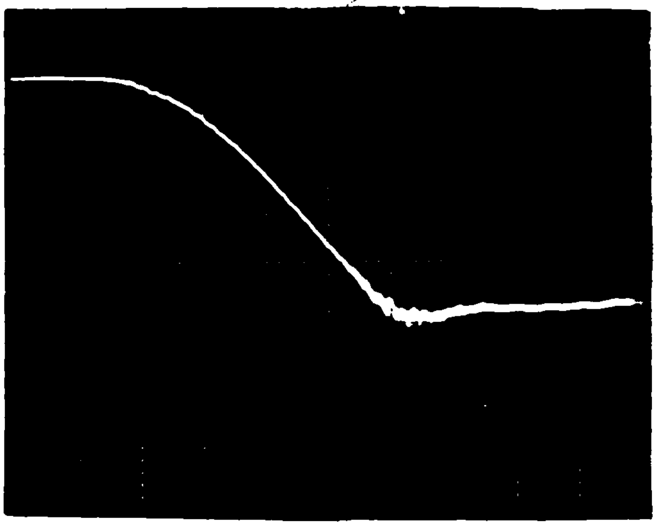
3500 MHz

FIGURE 4.49

VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

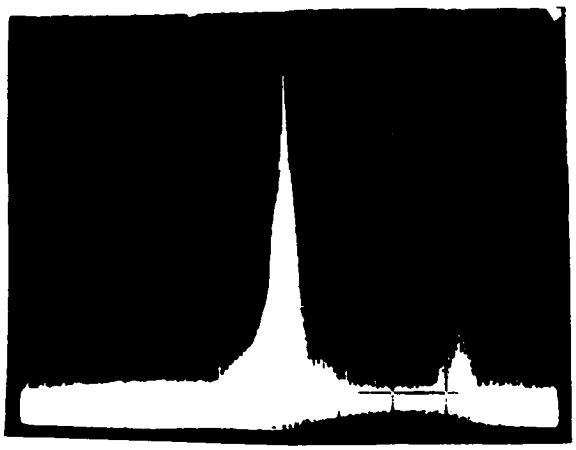
I_b = 40 ma

April 16, 1981



(a) Voltage

Horizontal = 0.2 μs/div.
Vertical = 10 KV/div.



(b) Spectrum

20 MHz/div.

Vertical 10 dB/div., 5 Sec. Sweep/div.

FIGURE 4.50

VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

I_b = 40 ma; F_o = 3700 MHz

April 16, 1981

TABLE 4.13

Test Results, Band IV Coaxial Magnetron, VMS-1104, S/N 1008,

Cavity B, Operating with SPN-43 Modulator

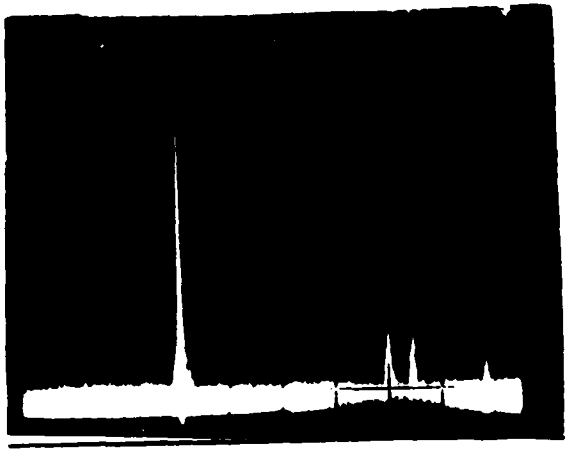
Test Date: April 16, 1981

Test Condition: Pulse Width = 0.95 μs; Duty Cycle = 0.00086;
Heater Voltage = 0.0 volts; Current (Avg.) = 40 ma

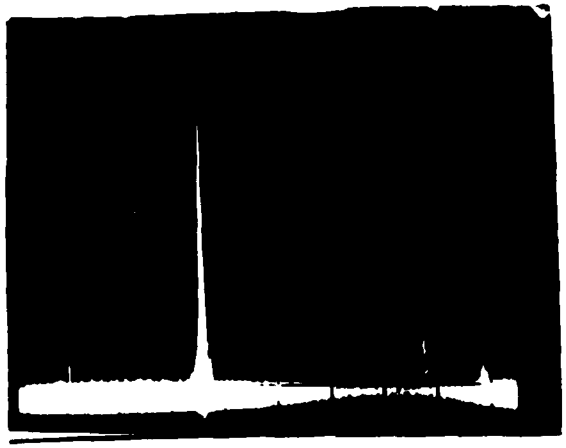
Frequency (MHz)	Stability (%) (1)	Stability (%) (2)
3500	0.00	0.06
3550	0.01	0.01
3600	0.00	0.00
3650	0.00	0.00
3700	0.00	0.00

(1) Matched load

(2) 1.5:1 VSWR at worst phase

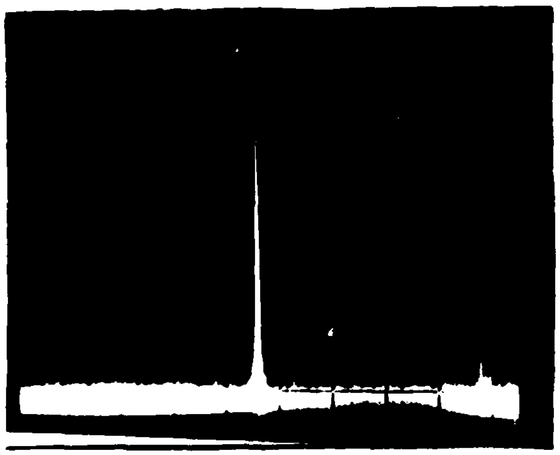


3500 MHz

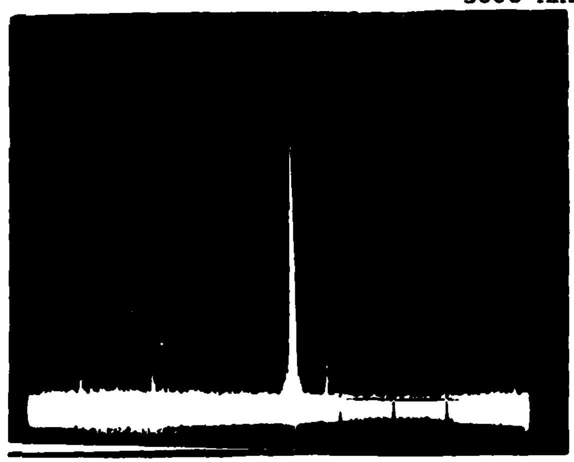


3550 MHz

3600 MHz



3650 MHz



3700 MHz

Horizontal = 100 MHz/div., Vertical = 10 dB/div., 300 KHz Resolution BW, 2 Sec. Sweep/div.

FIGURE 4.51

VMS-1104 Coaxial Magnetron, S/N 1008, AN/SPN-43 Varian

I_b = 40 ma, V_f = 0.0 volts

April 16, 1981

TABLE 4.14

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1008

CAVITY B, OPERATING WITH SPN-43 MODULATOR

Test Date: April 16, 1981

Test Conditions: Pulse Width = 0.95 µs; Duty Cycle = 0.00086; Heater Voltage = 40 Volts; Current (avg.) = 40 ma

Frequency (MHz)	Power (avg.) (watts) (1)	Power (Peak) (kw) (1)	Bandwidth (MHz) (2)	Side Lobe Ratio (dB) (2)	Stability (%)		Jitter (ns) (1)	Pushing (KHz/A) (1)
					(1)	(2)		
3500	740	860	1.2	10.5	0.01	0.04	3.0	17
3550	770	895	1.2	10.0	0.19	--	4.0	21
3600	780	907	1.2	10.0	0.06	0.60	3.0	21
3650	750	872	1.2	10.0	0.00	--	3.0	20
3700	690	802	1.15	10.0	0.00	0.00	3.0	22

(1) Matched Load

(2) 1.5:1 VSWR, Worst Phase

TABLE 4.15

TEST RESULTS, BAND IV COAXIAL MAGNETRON, VMS-1104, S/N 1008

CAVITY B, OPERATING WITH SPN-43 MODULATOR

Test Date: April 16, 1981

Test Conditions: Pulse Width = 0.95 µs; Duty Cycle = 0.00086; Heater Voltage = 0 Volts; Current (avg.) = 40 ma

Frequency (MHz)	Power (avg.) (watts)	Power (Peak) (kw)	Bandwidth (MHz)	Side Lobe Ratio (dB)	Stability (%) (1)	(2)	Jitter (ns)	Pushing (KHz/A)
3500	---	--	---	--	0.00	0.06	--	---
3550	---	--	---	--	0.01	0.01	--	---
3600	---	--	---	--	0.00	0.00	--	---
3650	---	--	---	--	0.00	0.00	--	---
3700	---	--	---	--	0.00	0.00	--	---

(1) Matched Load

(2) 1.5:1 VSWR, Worst Phase

TABLE 4.16

Additional Data

(April 17, 1981)

The following data pertain to the VMS-1104 coaxial magnetron:

a. Anode-Cathode Capacitance

S/N 1007R	42.9 pf
S/N 1008	38.9 pf

b. Tuning Data (S/N 1008 and Cavity "B")

Data of items (b) to (e) was taken under full power operation of the VMS-1104.

Number of Turns	Frequency (MHz)
0	3500.0
10	3510.7
20	3521.7
30	3533.0
40	3544.6
50	3556.6
60	3568.8
70	3581.3
80	3594.2
90	3607.4
100	3620.9
110	3634.8
120	3649.1
130	3663.7
140	3678.8
150	3694.2
154	3700.0

c. Tuner Torque (in-oz)

Frequency	cw	ccw
3500	20	18
3550	23	20
3600	21	18
3650	22	20
3700	22	20

d. Backlash

Frequency (MHz)	Backlash (KHz)
3500	220
3550	350
3600	220
3650	250
3700	340

e. Stop Limits

High Frequency Limit	3705.5 MHz
Low Frequency Limit	3495.8 MHz

5.0 PERFORMANCE OF BAND I, VMS-1054 COAXIAL MAGNETRON*

The Band I, VMS-1054 coaxial magnetron employing insert S/N 1002 was set up on the Varian test modulator, K-277. The modulator provided a voltage pulse of some 2 microseconds. The rate-of-rise of the voltage pulse was adjusted by adding a simple R-C network in parallel with the tube. The rise and fall time of the pulse may be further adjusted at a later time to provide an optimum pulse shape for this particular coaxial magnetron.

Typical qualification tests were made on the tube, and the data is presented in Table 5.1. These data show the excellent performance characteristics of the Band I device. The pushing characteristic as measured is surprisingly low; the measurements were rechecked and found to be accurate. Measurement of the leading edge jitter was made to establish the magnitude of time jitter to be expected from tubes of the VMS-1054 design.

Table 5.2 provides data on the peak and average power capability of the tube. Note one megawatt power at a duty cycle of 0.001 is achieved over the tuning range at the 65 ma level. Note also the performance of the tube at the 30 ma level where 500 kilowatts is generated at an efficiency of some 45-50%.

The spurious level from the tube was measured; data is given in Table 5.3. The spurious level observed was higher than expected based on preliminary evaluation of the tube. During the test it was observed the +200 MHz mode degraded to some -46 dB. Figure 5.1 shows the overall spurious level. This +200 MHz spurious

*Work on Band I coaxial magnetron was Air Force sponsored and funded.

TABLE 5.1

Test Results of Band I Coaxial Magnetron, VMS-1054, S/N 1002

Test Modulator: K-277; $I_{average}$ = 55 ma; tpc = 2.0 μs; duty = 0.001; V_f = 40 volts

Frequency (MHz)	Voltage (KV)	Power (kw)	Bandwidth (MHz) (1)	Bandwidth (MHz) (2)	Side Lobe Ratio (db) (1)	Side Lobe Ratio (db) (2)	Missing Pulses (%)	Pulling (MHz)	Pushing (KHz/amp)	Leading Edge Jitter (ns) (1)	Leading Edge Jitter (ns) (2)
2700	37.0	1020	0.60	0.60	-13.8	-13.0	0.00	0.8	3.0	3.8	6.2
2750	37.5	1050	0.60	0.60	-14.0	-12.0	0.00	0.8	1.0	3.9	5.9
2800	38.0	1030	0.60	0.62	-13.8	-12.5	0.00	0.8	2.0	3.0	2.4
2850	38.0	990	0.50	0.55	-13.0	-11.5	0.00	0.7	1.0	1.8	2.0
2900	38.5	900	0.55	0.60	-14.0	-12.0	0.00	0.8	1.0	2.6	3.4

(1) Matched Load

(2) 1.5:1 VSWR, Worst Phase

May 16, 1980

TABLE 5.2

POWER OUTPUT, VMS-1054, S/N 1002

	-Frequency-					
	2700 MHz		2800 MHz		2900 MHz	
Ib (ma)	V (kv)	Po (w)	V (kv)	Po (w)	V (kv)	Po (w)
5	30.0	120	30.9	130	31.8	120
10	32.0	180	33.0	200	33.8	170
15	33.0	250	34.1	290	34.5	245
20	33.9	350	34.9	390	35.2	320
25	34.2	440	35.5	480	35.9	400
30	34.8	520	35.8	590	36.0	490
35	35.2	630	36.0	690	36.5	560
40	35.9	720	36.5	770	37.0	655
45	36.1	800	37.0	880	37.5	730
50	36.5	900	37.8	970	38.0	800
55	37.0	1000	38.0	1050	38.2	890
60	37.5	1080	38.2	1130	38.9	960
65	37.8	1180	38.5	1230	39.0	1060

May 19, 1980

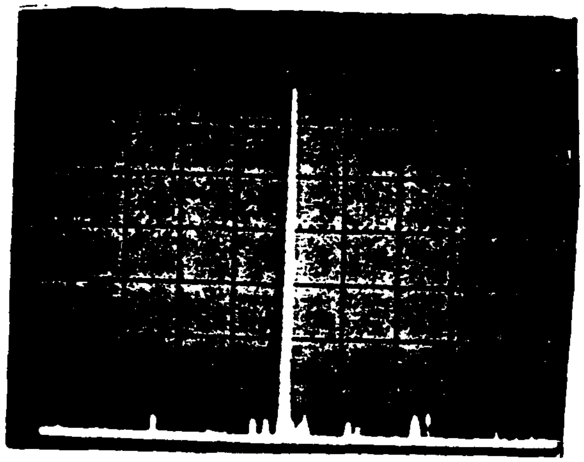
TABLE 5.3

SPURIOUS LEVELS, BAND I, VMS-1054, S/N 1002

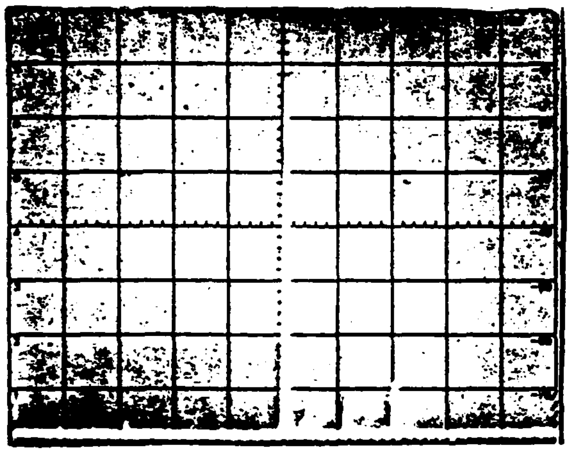
$I_b = 55$ ma

Frequency (MHz)	Spurious Frequency	Level Relative to F_0 (dB)
2900	+200 MHz	-50
	121 Mode	Not Detected
2800	+400 MHz	-50
	121 Mode	-58
2700	+500 MHz	-55
	+225 MHz	-58
	121 Mode	-48

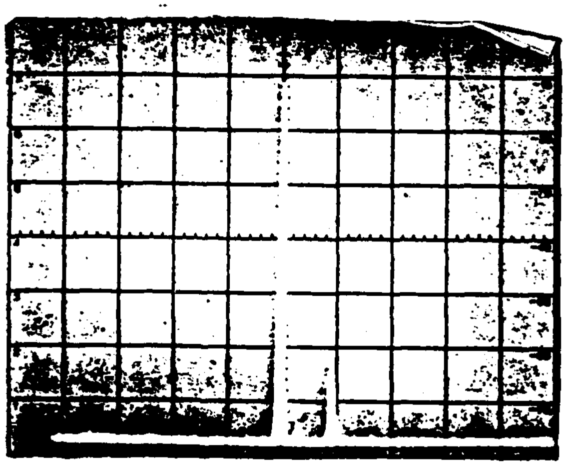
May 19, 1980



2700 MHz



2800 MHz



2900 MHz

200 MHz/div.

FIGURE 5.1

VMS-1054, S/N 1002, K-277 Test Modulator

I_b = 60 ma; Duty = 0.001; V_f = 55 volts

August 20, 1980

mode showed a time dependent behavior with a level of less than -60 dB at turn on of the tube to the -46 dB after thermal stabilization.

An investigation of this phenomena resulted in the refurbishing of the cavity. General performance was reevaluated and found to be in good agreement with that of Table 5.1. Improvement in leading edge jitter was obtained with values of 2.5 nanoseconds recorded.

Figures 5.2 to 5.7 show video and spectrum performance. Note the +400 MHz mode was suppressed, and spurious is -60 dB or better except at 2900 MHz where the +200 MHz mode is some -56 dB. This mode still showed some time dependence.

The vacuum insert was rotated in the cavity by 180° to check if the +200 MHz had some symmetry dependence. Figures 5.8 to 5.10 show video and spectrum.

At the 60 ma level, the spurious level is -60 dB and was not time dependent.* In Figure 5.11 we show the effect of increasing the voltage level on the tube to provide some 70 ma of average current. Note the level of the +200 MHz mode has increased from -60 dB to -56 dB. These data in conjunction with the video current data indicate the +200 MHz mode is excited on the trailing edge of the voltage pulse. Reducing the fall time of the voltage pulse by optimizing the impedance level of the pulse forming network of the modulator should further reduce the overall spurious level below -60 dB at the 60 ma current level.

During the final evaluation tests of the Band I tube, S/N 1002, the heater shorted. The tube was satisfactorily operated the previous day, and turn down followed normal procedures. The

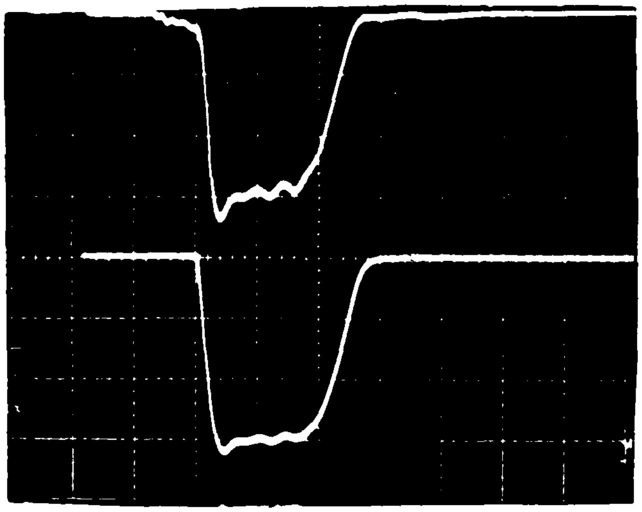
*Note to insure proper orientation in the cavity, the vacuum inserts will be designed with a suitable keyway.

following morning the heater was observed to be a short condition. The short was intermittent in that a reorientation of the tube's position could remove the short; however, the short subsequently returned. It is of interest to note that similar short problems were also experienced in the field in a production magnetron which employs this identical cathode. The heater support ceramics are found to fracture, the heater shifts in position, and a short occurs. In the case of the production magnetron, the fracture of the ceramic results from a snap-on start condition which places an exceptionally high voltage across the cold heater element with subsequent excess input power to the ceramic. It is believed the present design of the ceramic is such that large axial tensile stress is created at the central core of the ceramic. Corrective actions taken were reduction in level of heater input power, redesign of the ceramic to that of a thin walled cylinder to relieve the stress at the core of the present ceramic, and the incorporation of suitable mechanical supports such that if the ceramic were to fracture, the heater windings could not short to the ID of the matrix support sleeve.

The shorted cathode was removed from the insert, inspected and found to have a cracked ceramic as noted above. In the standardized program, this is the first cathode to experience a failure of this nature.

A series of measurements made on the redesigned production ceramic has confirmed that failure due to thermal shock can be

eliminated via the use of a thin wall ceramic cylinder. In addition, in the standardized magnetron, the preheat conditions are substantially below that of the production conditions, thus high reliability is expected. This must be qualified to some degree in that the standardized tube is expected to operate at a duty cycle of 0.001 as compared to 0.00067 for the production tube. The fact that we have had only one failure out of a total of thirteen devices indicates the duty factor aspect is less severe than the preheat snap-on consequences. It is planned that any new standardized tube construction will incorporate the latest production design of the heater support ceramic.

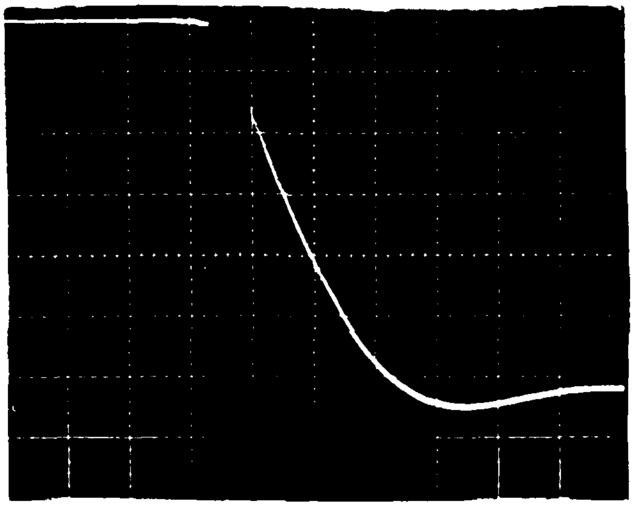


Anode Current

Vertical 20 A/Div.

Detected RF Pulse

Horizontal = 1.0 μs/div.



Detected RF Pulse

Expanded Horizontal

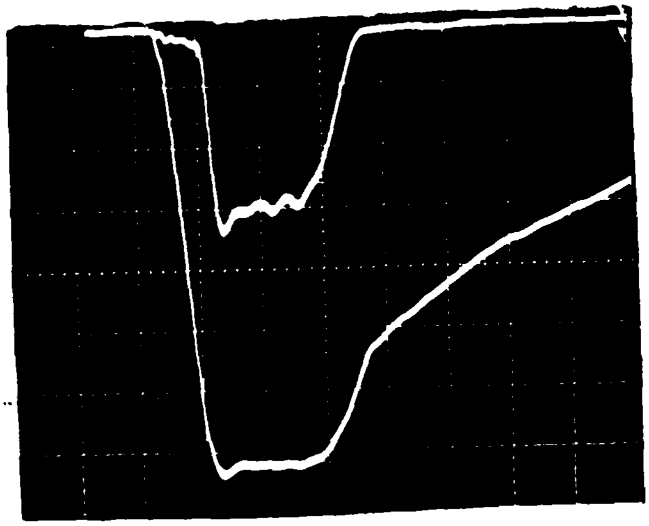
Scale 0.1 μs/div.

FIGURE 5.2

VMS-1054, S/N 1002, Test Modulator K-277

I_b = 60 ma; Duty = 0.001, Frequency = 2800 MHz

April 15, 1980



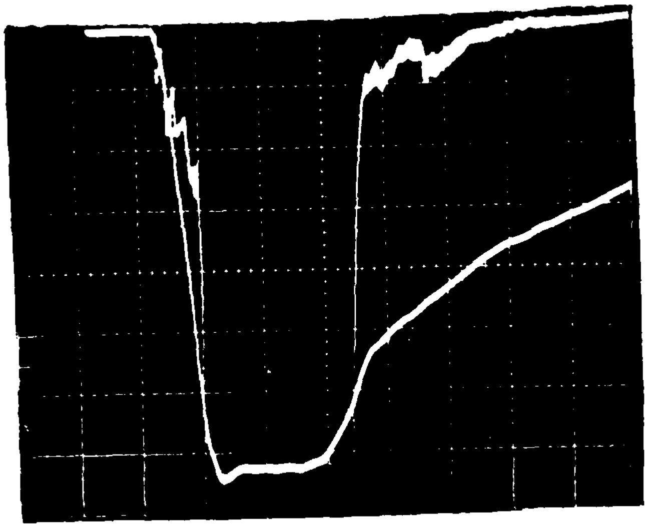
Anode Current

Vertical 20 A/div.

Anode Voltage

Vertical 5 KV/div.

Horizontal 1.0 μs/div.



Anode Current

Vertical 2.0 A/div.

Anode Voltage

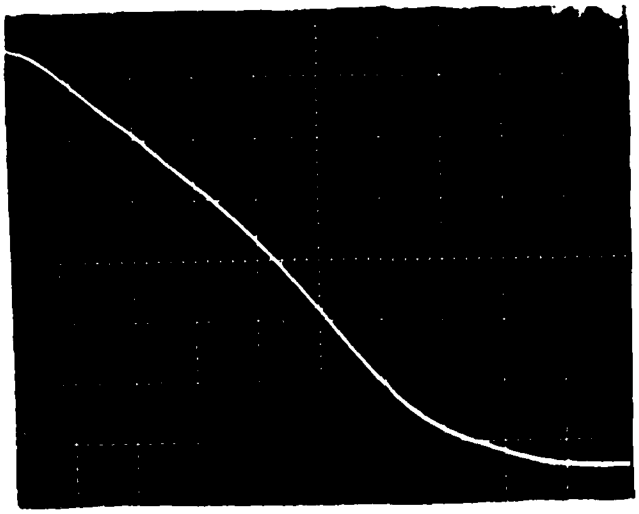
Vertical 5 KV/div.

Horizontal 1.0 μs/div.

FIGURE 5.3

VMS-1054, S/N 1002, Test Modulator K-277

I_b = 60 ma; Duty = 0.001; Frequency = 2800 MHz



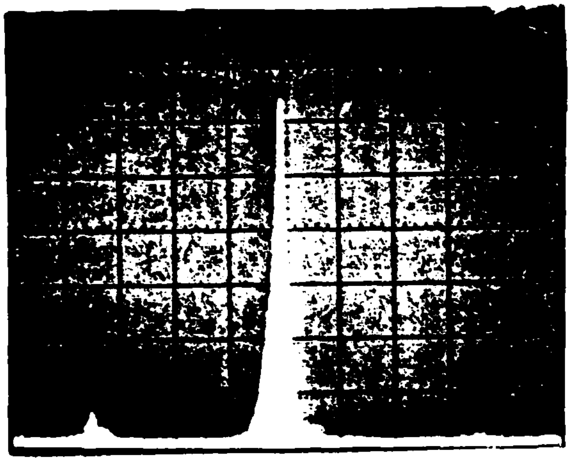
Vertical 5 KV/div.

Horizontal 0.1 μs/div.

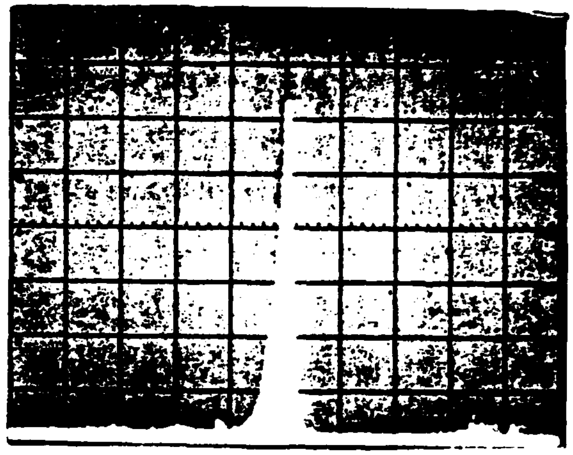
Rate of Rise 60 KV/μs (approx.)

FIGURE 5.4

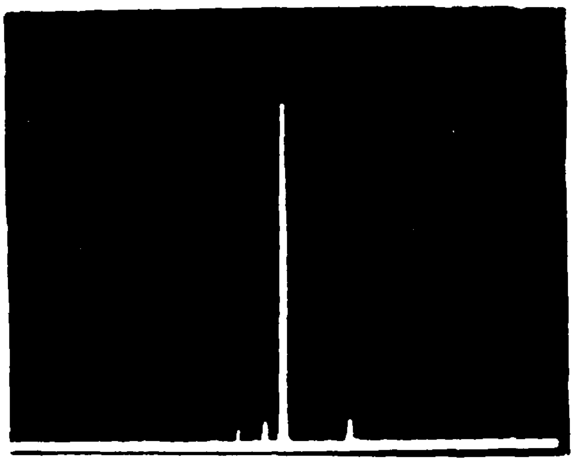
Voltage Pulse - Expanded Scale



20 MHz/Div.

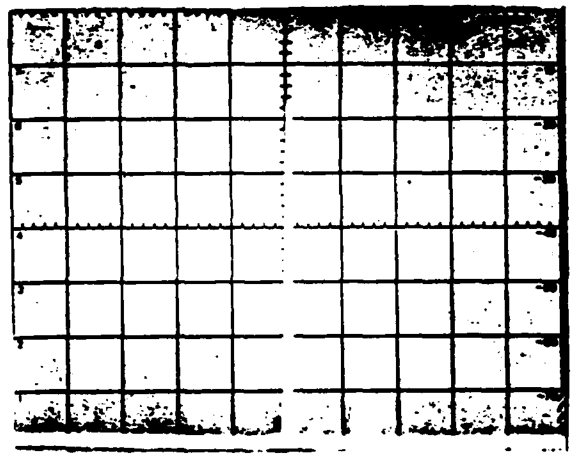


20 MHz/Div.



200 MHz/Div.

2700 MHz



200 MHz/Div.

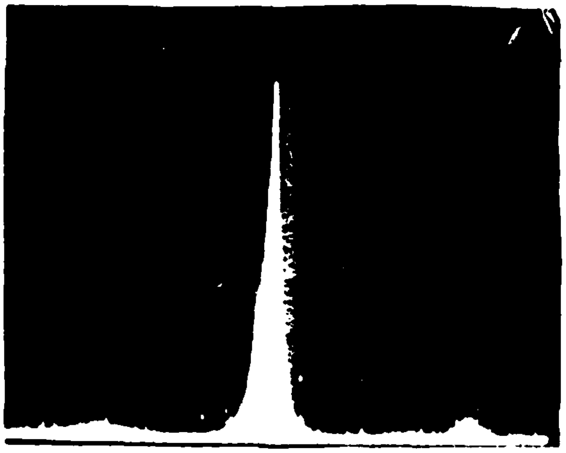
2750 MHz

FIGURE 5.5

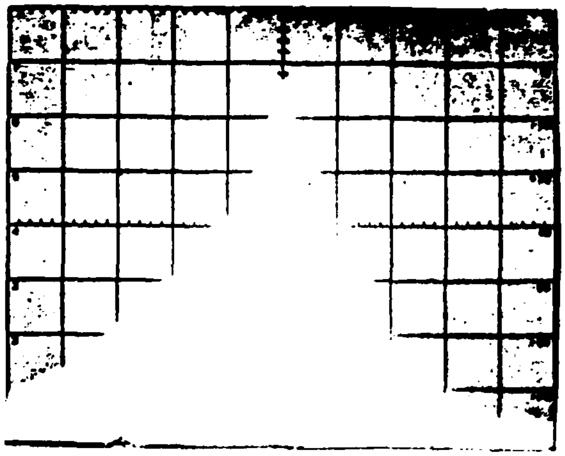
VMS-1054, S/N 1002, Test Modulator K-277

I_b = 60 ma; Duty = 0.001

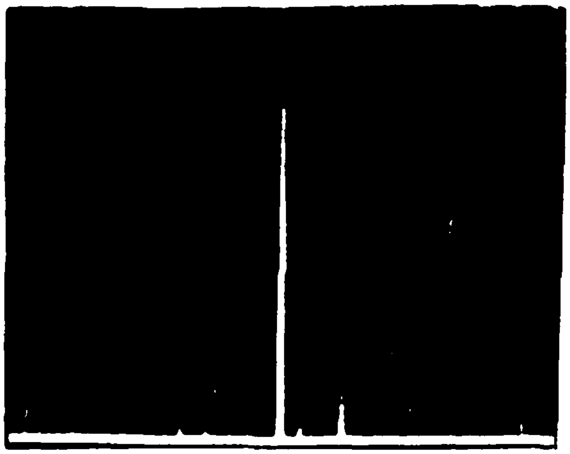
8/15/80



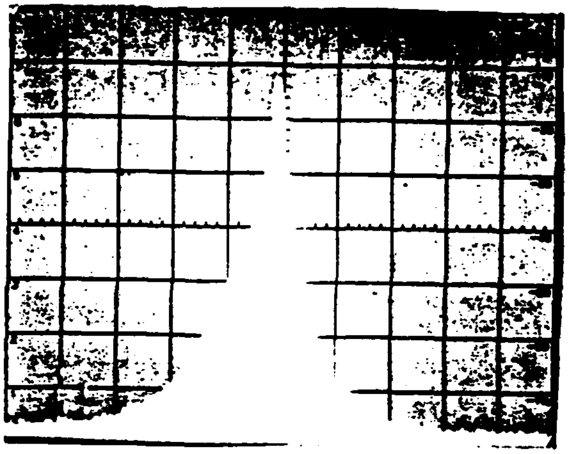
20 MHz/Div.



2 MHz/Div.



200 MHz/Div.



5 MHz/Div.

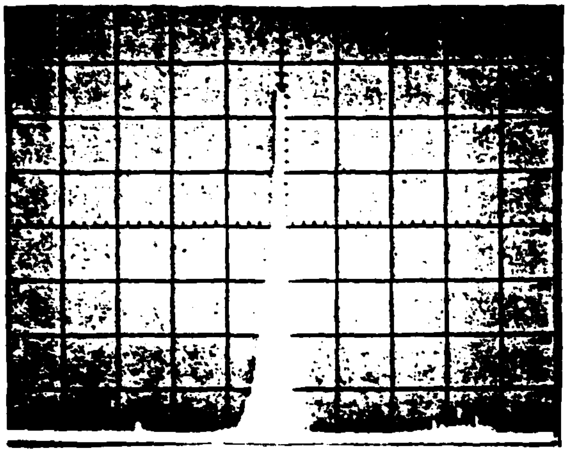
2800 MHz

FIGURE 5.6

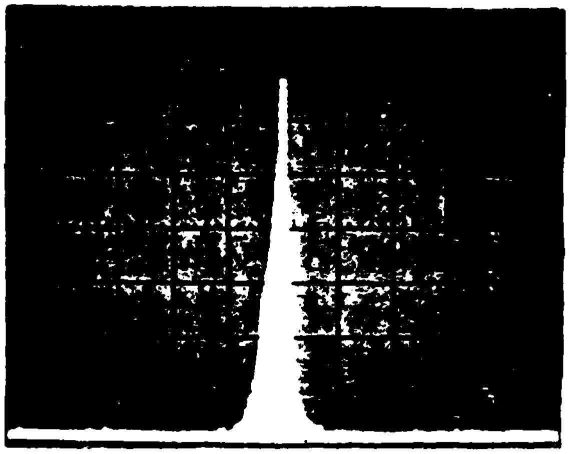
VMS-1054, S/N 1002, Test Modulator K-277

I_b = 60 ma; Duty = 0.001

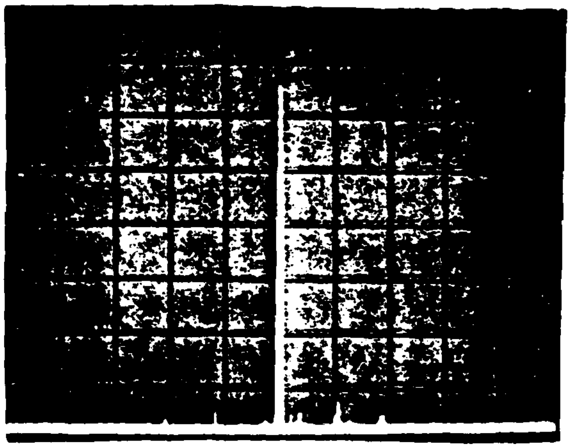
8/15/80



20 MHz/Div.

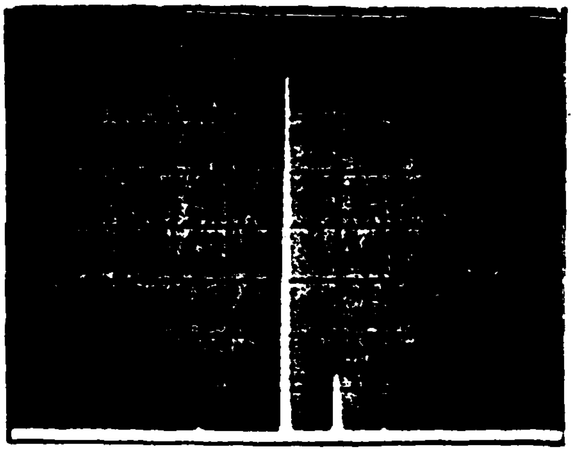


20 MHz/Div.



200 MHz/Div.

2850 MHz



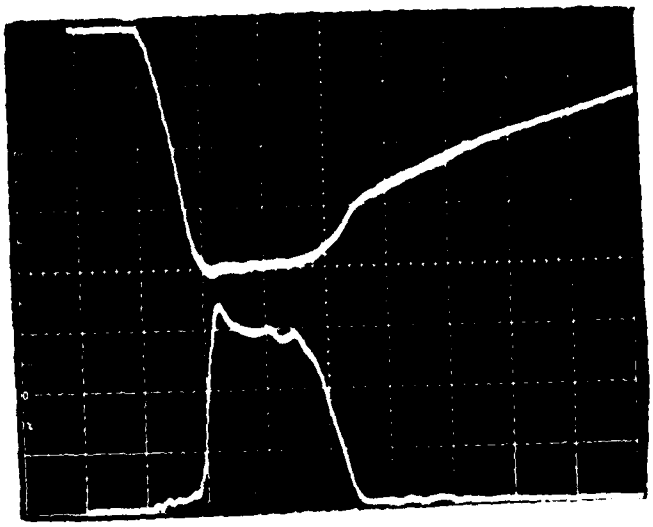
200 MHz/Div.

2900 MHz

FIGURE 5.7

VMS-1054, S/N 1002, Test Modulator K-277

I_b = 60 ma; Duty = 0.001

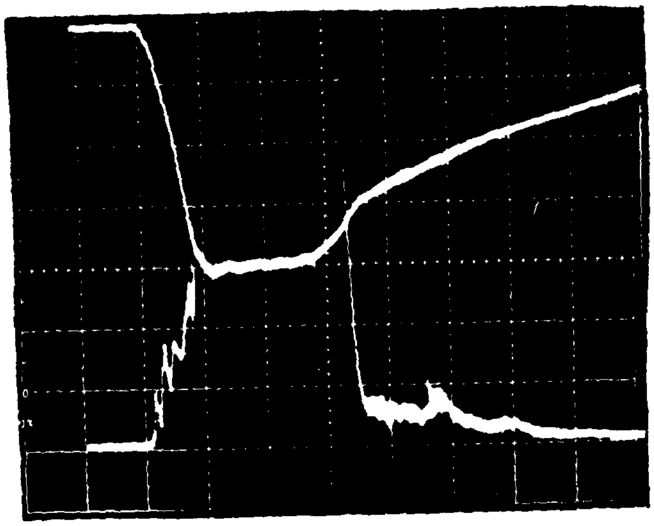


Voltage 10 kV/div.

Detected RF Pulse

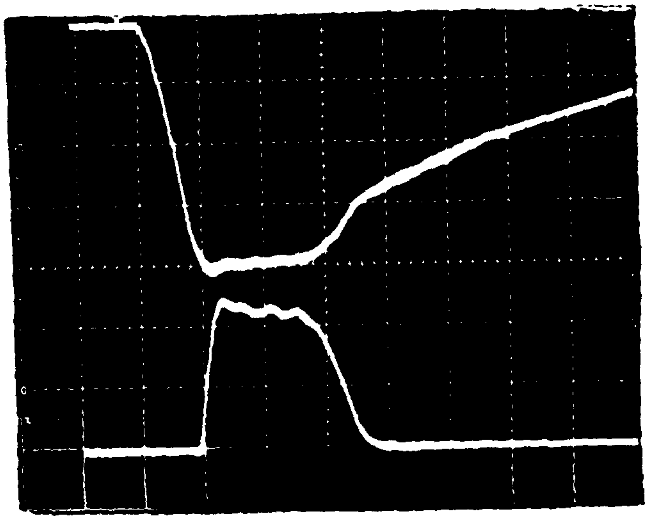
fo = 2800 MHz, 60 ma

Horizontal = 1 μs/div.



Voltage 10 kV/div.

Current 20 A/div.



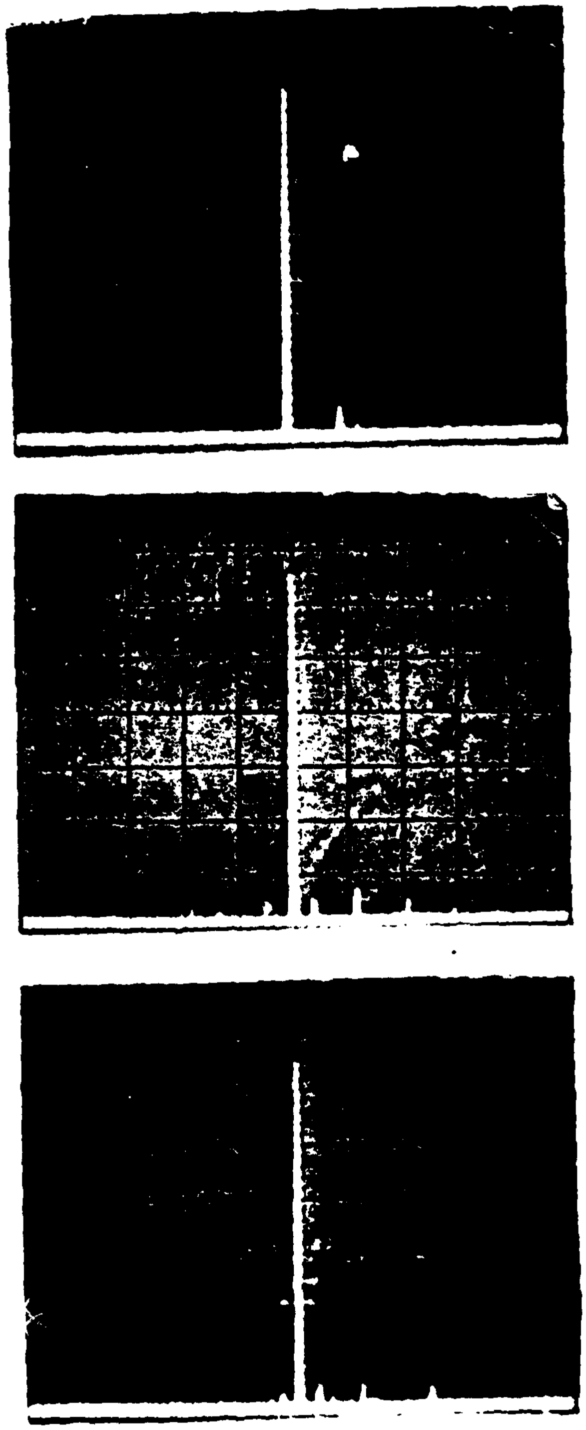
Voltage 10 kV/div.

Current 2.0 A/div.

FIGURE 5.8

180 Degree Rotation of Insert S/N 1002

August 27, 1980



2900 MHz

2800 MHz

2700 MHz

200 MHz/div.

FIGURE 5.9

180 Degree Rotation of Insert S/N 1002

I_b = 60 ma; V_f = 45

August 28, 1980

Spurious Less Temperature Sensitive

-60 MHz excited to a greater degree.

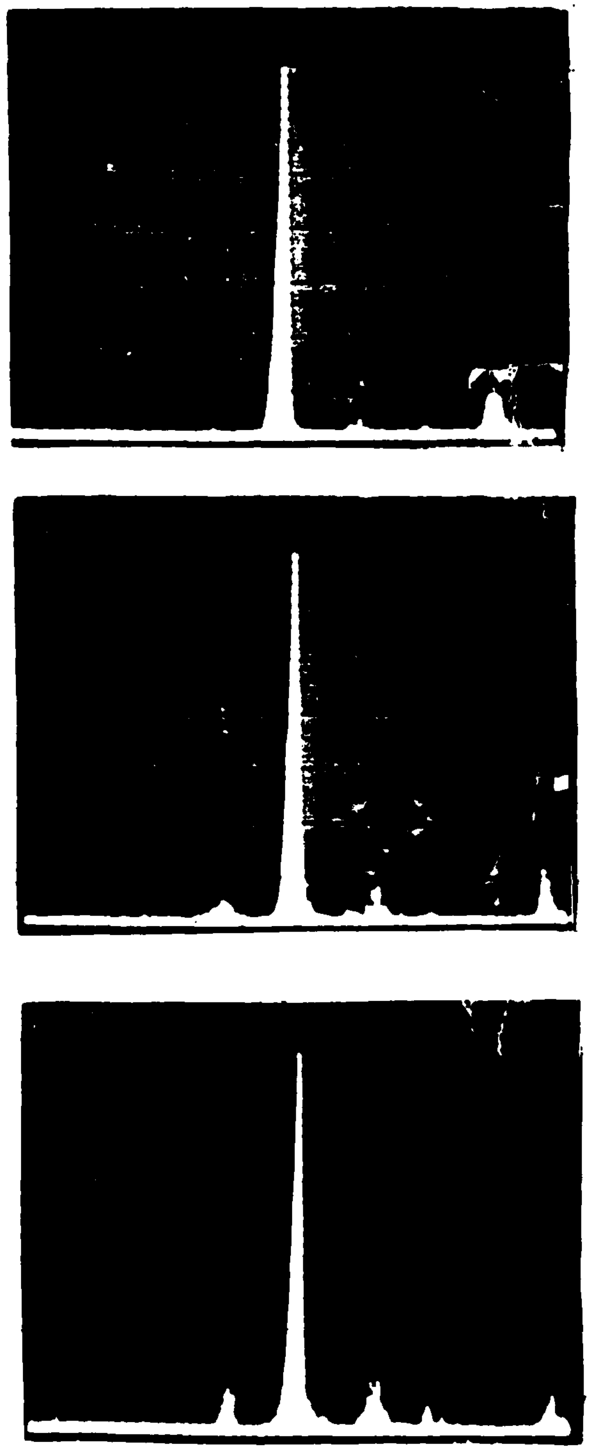
I_b = 60 ma; V_f = 45 volts

Horizontal = 50 MHz/div.

2900 MHz

2800 MHz

2700 MHz

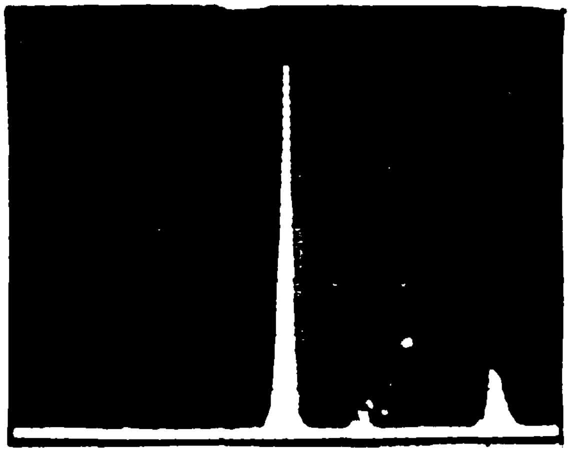


50 MHz/div.

FIGURE 5.10

180 Degree Rotation of Insert S/N 1002

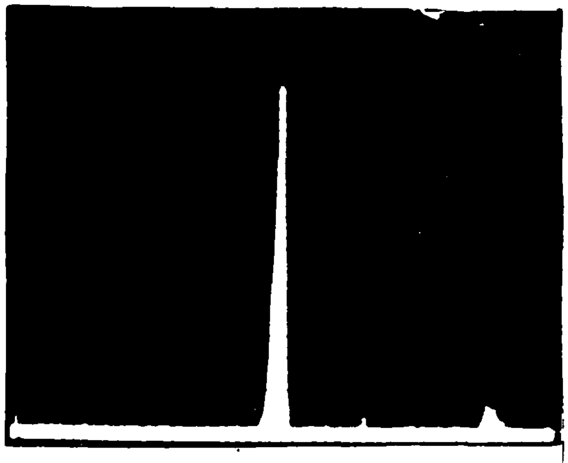
August 28, 1980



50 MHz/div.

Shows increase is +200 MHz as V_b increased (trailing edge effect)

I_b = 70 ma; P = 1040 watts



50 MHz/div.

60 ma

200 MHz/div.

60 ma

FIGURE 5.11

180 Degree Insert Rotation

Spurious Level at I_b = 70 ma

6.0 CONCLUSIONS

1. A VMS-1104, Band IV coaxial magnetron was constructed and evaluated at Varian/Beverly in both a test modulator and in the Varian SPN-43 modulator. In the test modulator the tube was operated over the tuning range at the one megawatt peak power level at a duty cycle of 0.001. Spurious signal generation was -50 dB or better.

This tube was delivered to the NESEA facility with a SPN-43 modification kit. The tube and modification kit was operated satisfactorily in the SPN-43 radar system at NESEA.

2. A second VMS-1104 tube and a spare vacuum insert were constructed and evaluated at Varian. RF performance consistent with the first tube was obtained. These devices were made available to the Navy.

3. A VMS-1054, Band I, coaxial magnetron was constructed and evaluated at Varian/Beverly in the same test modulator used to evaluate the Band IV tubes. Power level was one megawatt at a duty cycle of 0.001. The tube demonstrated a spurious level approximating -60 dB. On final test the tube developed a heater short; the tube is available for reconstruction.

4. Specifications for the tubes and drawings of the cavity, vacuum insert and modification kit were delivered.

-APPENDIX-

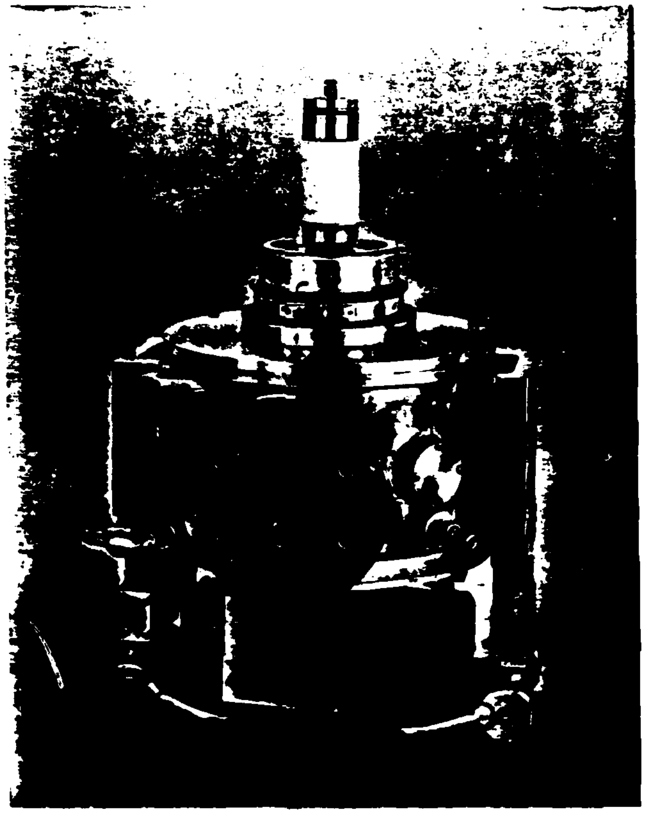
1. PHOTOGRAPH OF VMS-1104, BAND IV, STANDARDIZED COAXIAL MAGNETRON.

2. PHOTOGRAPH OF VMS-1054, BAND I, STANDARDIZED COAXIAL MAGNETRON.

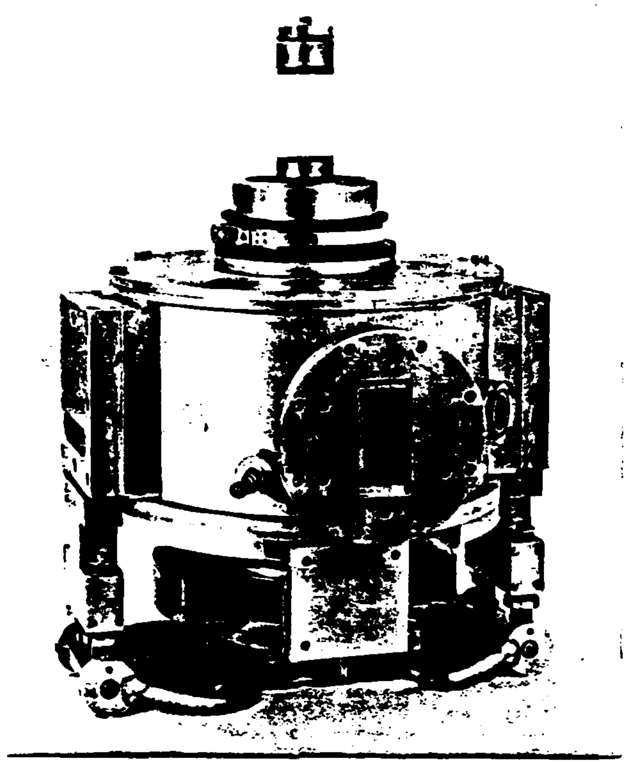
3. TEST SPECIFICATION--VMS-1104

4. TEST SPECIFICATION--VMS-1054

5. DRAWING--STANDARDIZED MAGNETRON VACUUM INSERT (SK-33941)



VMS-1104 COAXIAL MAGNETRON



VMS-1054 COAXIAL MAGNETRON

VMS-1054

CEM^{R} COAXIAL MAGNETRON

TEST SPECIFICATION

TENTATIVE

varian

SPECIFICATION APPROVAL SHEET		SPEC. NO.	
		DEVICE TYPE	
MODEL NO.: VMS-1054	TENTATIVE	WRITER	T. Ruden
TITLE: CEM[R] COAXIAL MAGNETRON		DATE	3/4/81
		PAGE OF	REV.
ENG. T. E. Ruden	MFG. Frank Trujillo	Q.C.	MARKETING

	LOCATION	ECO NO.	DESCRIPTION	DATE	APPROVAL

The provisions of the latest issue of MIL-E-1 apply to this specification

DESCRIPTION Tunable frequency, integral magnet, air cooled, 1000 kw min. power output, 2.7 - 2.9 GHz

ABSOLUTE MAXIMUM AND MINIMUM RATINGS: Note 1

INDEPENDENT

PARAMETER	If Surge	tk	VSWR	Tuner Torque	Body Temp	Input Bushing Temp	Pressurization Input	Pressurization Output	epy	
UNITS	a	sec		in-oz	°C	°C	psia	psia	kv	
MAXIMUM	17	--	1.5/1	40	125	270	30	30	50	
MINIMUM	--	480	---	--	-50	--	13	15	--	
NOTES	25	16		2	3	3	4	--	--	

DEPENDENT

PARAMETER	Ef	If	Ib	Pi	pi	Du	tpc	prr	rrv
UNITS	V	A	a	W	kw	——	μsec	pps	kv/μsec
MAXIMUM	66	3.5	60	2640	2640	.001	2.0	1150	65
MINIMUM	--	--	20	--	--	--	0.75	--	55
NOTES	5,16						6		7

MECHANICAL

MOUNTING POSITION ______ Any, See Note 21

SUPPORT ______ Cradle Mount

COOLING ______ Forced air (See Note 8)

OUTLINE ______ See Figure 1

MAGNET ______ See Note 9

COUPLING ______ Mates with UG-585A/U Flange

NET WEIGHT ______ 65 pounds nominal

Cavity Pressure ______ 20 psig, SF_6, See Note 15

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	LIMITS MAX	UNITS
	General					
---	Marking	Figure 1	---	---	---	---
---	Holding Period		---	168	---	hrs
---	Dimensions	Figure 1	---	----	---	---
4.2	Qualification					
1143	Air Cooling	Osc. (1); T_A=25°C ± 5°C (Notes 8, 11, 12)	T	---	85	C° Rise
---	Shock	G=30; t=11ms ± 1ms No Voltages (Notes 14 & 22)	---	---	---	---
4309	Phase of Sink	No Voltages, F = F3	---	0.3	0.5	DΛ g obj
---	High Frequency Vibration	No Voltages, F = 50 Hz (Notes 14 & 27)	---	---	---	---
---	Preparation for Delivery	Note 29	---	---	---	---
4.6	Life Test	Note 23	t ---	2000 494	--- ---	hrs cycles
	Quality Conformance Inspection, Part I	Notes 19, 30				
1301	Heater Current	Ef=66VAC;tk=480 Sec. Min.	If	2.00	3.50	A
---	Coupling	VSWR = 1.05 Max	---	---	---	---

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	LIMITS MAX	UNITS
4303	Heater-Cathode Warm-up Time	Ef=66VAC; tk=480 Sec (Notes 5,16)	---	---	---	---
4304	Pulse Characteristics	tpc=0.9 ± 0.10 s; Du = 0.001 rrv = 55 kv/µs min. Notes 6 & 7				
---	Average Anode Current	Ib = 55 mAdc	---	---	---	---
4306	Pulse Voltage	F = F1-F3	epy	34	42	kv
4250	Power Output	F = F1-F3 (Notes 18 & 28)	Po	1000	---	W
4308	Spectrum Measurements	F = F1-F3 (Note 17)				
	Radio Frequency Bandwidth		BW	---	2/tpc	MHz
	Spectrum Side Lobes		SL	9	---	dB
4315	Stability	F = F1-F3 (Note 20)	MP	---	0.25	%
4223 4.8.14	Tunable Frequency	Upper Limit Lower Limit (Note 13)	F F	F3 ---	--- F1	MHz MHz
	Quality Conformance Inspection, Part II	Notes 10, 19, 24				
4310	Pulling Factor	F=F1, F2, F3, Osc.(1) (Note 26)	F	---	2.5	MHz
4311	Pushing Factor	F=F1, F2, F3, ib = 50-60A Osc.(1)	FΔA	---	30	KHz/A

varian

TEST SPECIFICATION

Type No. VMS-1054 Page 5 Of 12

Effective ________ Revision ________

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	LIMITS MAX	UNITS
---	Spectrum Measurements	Osc (1)				
	RF Bandwidth	-40 dB Level	F	---	10/tpc	MHz
	Spurious Radiation	Outside 10/tpc	Level	-55	---	dB
4003	Pressurization	Cavity, SF_6 Note 15	---	20	25	psig
---	Tuner Drive Torque	$25^oC \pm 5^oC$ No Voltages	Torque	---	40	in-oz
	Life Test End Points (From Qualification)					
4250	Power Output	Osc(1); F1-F3	Po	800	---	watts
4308	Radio Frequency Bandwidth	Osc(1); F1-F3 Note 17	BW	---	2.5/tpc	MHz
4308	Spectrum Side Lobes	Osc(1); F1-F3 Note 17	SL	6	---	dB
4315	Stability	Osc(1); F1-F3 Note 20	MP	---	0.5	%

NOTES:

1. The requirements of paragraph 6.5 of MIL-E-1 shall apply. For the assistance of designers of electronic equipment, the ratings have been divided into two groups as follows:

   a) Independent: Ratings which may be obtained simultaneously.
   b) Dependent: Ratings which are interrelated and may not necessarily be obtained simultaneously.

2. The tuner drive shall be capable of supplying a minimum of 30 inch-ounces of torque to the magnetron tuning shaft and shall never supply more than 40 inch-ounces of torque (including inertial effects) under stable conditions.

3. The temperature is to be measured at the point indicated on Figure 1, TMAX under conditions of Osc(1); TMIN under conditions of No Oscillation, No Heater Power.

4. The magnetron shall be capable of normal operation without electrical breakdown with the input bushing at normal atmospheric conditions.

5. Prior to the application of high voltage, the cathode shall be heated to the required initial operating temperature. This shall be done by applying 66 volts ± 5 percent for 480 seconds minimum. On the application of anode voltage, the heater voltage must be reduced according to the following:

   $E_f = 40 \pm 5\%$ volts $\quad 750 \le P_i \le 1900$ W

   $E_f = 30 \pm 5\%$ volts $\quad 1900 < P_i \le 2640$ W

   For prolonged standby:

   $E_f = 66 \pm 5\%$ volts

6. The characteristics of the applied pulse must be those which result in proper starting and oscillation. The rate of rise of the voltage pulse, the percentage of pulse voltage ripple, and the rate of pulse voltage fall are among the more important considerations. The tube manufacturer should be consulted regarding pulse characteristics as related to the specific application.

7. The rate of rise of voltage (rrv) shall be measured in accordance with MIL-E-1 Method 4304, except that the steepest tangent to the leading edge of the voltage pulse shall be measured above the 70 percent amplitude point.

8. The cooling required is partially determined by the total power input to the magnetron. The following table gives MINIMUM air flow and back pressure values that are deemed necessary to limit the body temperature to a maximum of 125°C at an ambient temperature of 40°C at sea level.

Total Magnetron Power Input (Watts)	Cooling Air Flow Cu.Ft/Min.	Air Pressure at Entrance to Cooling System Inches of Water
Standby Condition	20	1.0
2640	100	2.5

9. In handling and mounting the magnetron, care must be exercised to prevent demagnetization. Maintain minimum clearance of 8 inches between magnet materials, steel tools, plates, etc., and 12 inches between other magnets.

10. The following code defines the test frequencies:

F1	F2	F3
F1 = 2700 MHz	F2 = 2800 MHz	F3 = 2900 MHz

11. Temperature measurements shall be made only after thermal equilibrium has been reached.

12. With the specified airflow, using a conduit which fits snugly to the cooling fins, the rise above ambient specified shall not be exceeded.

13. The tuning mechanism shall operate as specified over the entire frequency range. The number of turns of the tuner shaft required to tune from F1 to F3 shall be nominally 250.

14. Prior to, and after completion of this test, the tube shall meet the pulse voltage and power output tests of Osc (1).

15. The specified pressure shall be applied to the cavity. Consult tube manufacturer for SF_6 gas specification and cavity purge procedure.

16. 480 seconds required for Ef of 66V.

17. The radio frequency bandwidth and side lobes shall be within the limits specified when a VSWR of 1.5 minimum is introduced in the load at a distance of 0.2 ± 0.05 meters from the magnetron flange and the phase is adjusted at the start of each measurement to produce maximum degradation.

18. The minimum power output requirement must be satisfied over the specified frequency band. See note 10.

19. Unless otherwise specified, all tests required by this specification shall be made under the following atmospheric conditions:

    Ambient Temperature, T_A = 25 ± 10°C
    Relative Humidity = 90% or less
    Barometric Pressure = Local Standard

20. Stability shall be measured in terms of the average number of output pulses missing, expressed as a percentage of the number of input pulses applied during the period of observation. The missing pulses (MP) due to any causes, are considered to be missing if the RF energy is less than 70 percent of the normal energy level. The stability shall be measured when a VSWR of 1.5 minimum is introduced in that phase producing maximum instability.

21. Tube manufacturer should be consulted on cradle mount design for specified orientation.

22. The tube shall be subjected to 9 impact shocks of 50g, consisting of three shocks in opposite directions along each of three axes perpendicular to planes A, B, and C, Figure 1, with each shock impulse having a time duration of 11± 1 milliseconds. The "g" value shall be within 10 percent when measured with a .2 to 250 cps filter, and the maximum "g" shall occur at approximately 5-1/2 milliseconds.

23. The intermittent life test shall be conducted while the phase of 1.5 minimum VSWR located at a distance of 0.2 ± 0.05 meters from the magnetron flange is uniformly and continuously cycled through 260 electrical degrees with a time inteval of approximately 30 minutes per cycle. Simultaneously the magnetron frequency, starting at F1, increasing to F3, then decreasing to F1 shall be changed approximately 100 Megahertz approximately every 50 hours.

Condition	Ib(mAdc)	Ef(Vac)	Duration(Minutes)
Standby	0	66	8
Osc(1)	55	30	225
Off	0	0	10

This cycle to be repeated until the accumulated radiate time equals the specified life.

24. Rejection and resubmittals shall be in accordance with MIL-STD-105, Section 12. The AQL of the combined defectives for attributes in Quality Conformance Inspection, Part 1 excluding inoperatives, shall be 1 percent.

25. The internal impedance of the heater filament supply shall limit the surge current to the maximum specified.

26. The procedure in MIL-E-1 Method 4310 shall be followed.

27. The tube shall be mounted in a rigid fixture and vibrated with a simple harmonic motion at a double amplitude (total excursion) or .006 inch. The tube shall be vibrated in three axes for a period of one minute in each axis. The axes of vibration shall be perpendicular to planes A, B and C as shown on the outline drawing, Figure 1.

28. It shall be an objective of the initial procurement to specify a tube with the final ratio of the maximum power specification to the minimum power specification of 1.4. The final specification must fall within the stated limis given this current specification.

29. Preparation for delivery

a. Packaging and Packing. Electron tube shall be packaged in accordance with MIL-E-75 package, Group 9. Electron tubes shall be cushioned and positioned in a snug-fitting metal, plastic or other suitable container which will pass the tests of MIL-E-75.

b. Marking. Containers shall be marked in accordance with MIL-E-75, or as specified in the contractor order.

30. The modulator shall be sich that the energy per pulse delivered to the tube, if arcing occurs, shall not greatly exceed the normal energy per pulse. The tube heater shall be protected against arcing by use of a connector that places a minimum of .05 μf across the heater directly at the input terminals.

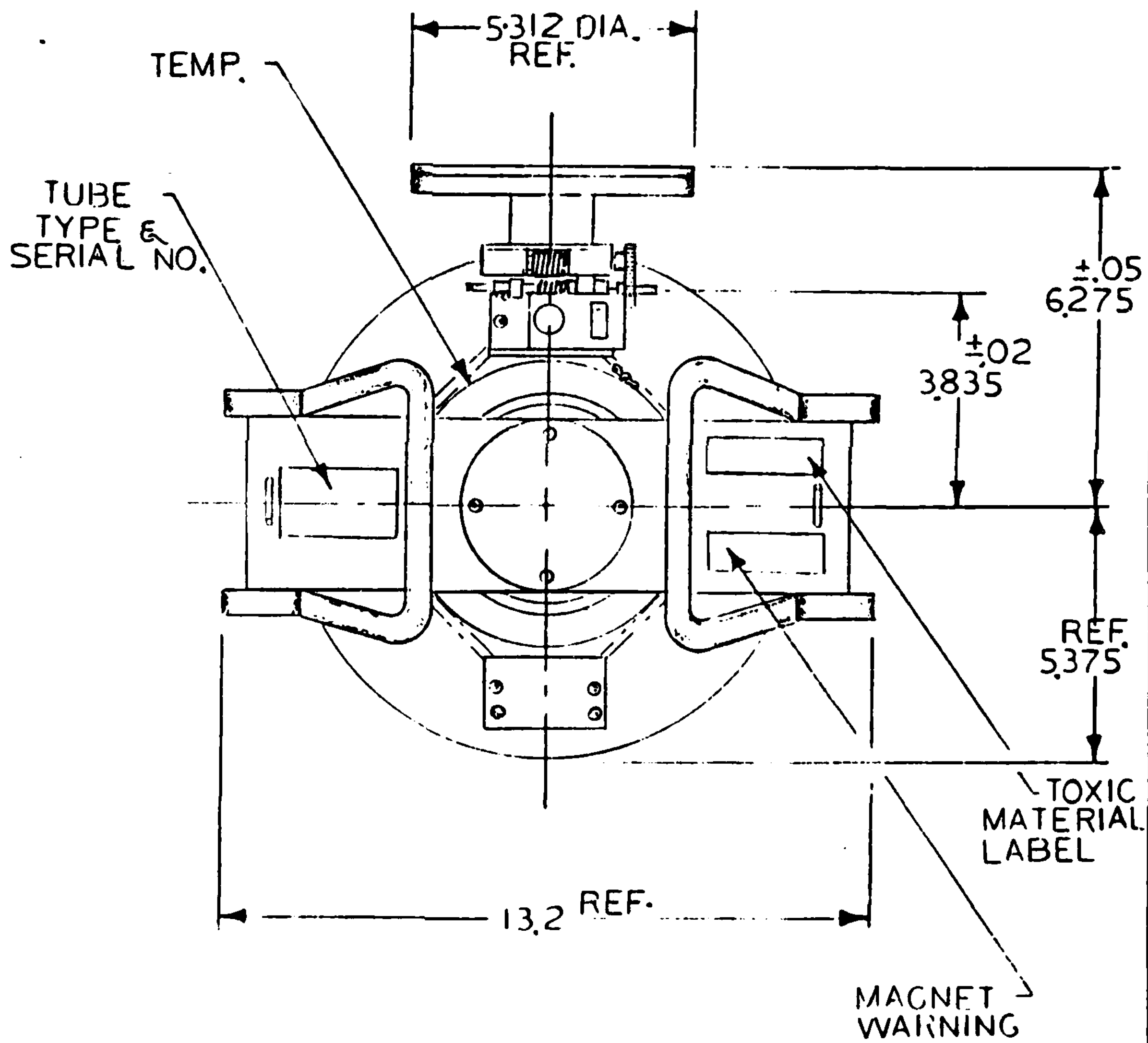

5.312 DIA. REF.
TEMP.
TUBE TYPE & SERIAL NO.
±.05
6.275
±.02
3.835
REF.
5.375
TOXIC MATERIAL LABEL
13.2 REF.
MAGNET WARNING

FIGURE I

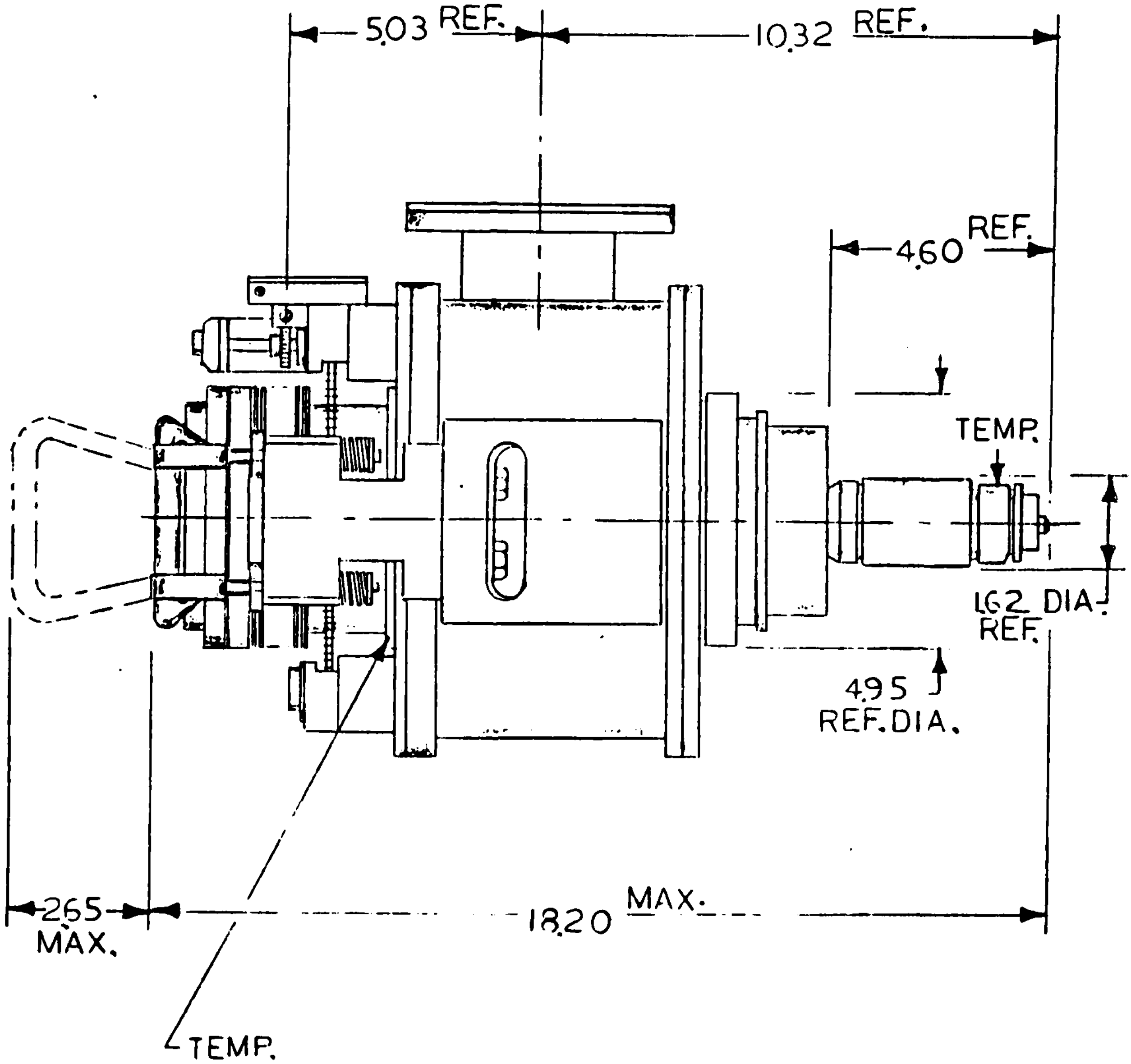

5.03 REF.
10.32 REF.
4.60 REF.
TEMP.
1.62 DIA.
REF.
4.95
REF. DIA.
2.65
MAX.
18.20 MAX.
TEMP.

FIGURE Ia

VMS - 1104

CEM[R] COAXIAL MAGNETRON

TEST SPECIFICATION

TENTATIVE

varian

SPECIFICATION APPROVAL SHEET

SPEC. NO.	
DEVICE TYPE	
WRITER	T. Ruden
DATE	3/4/81
PAGE OF	REV.

MODEL NO.: VMS-1104 TENTATIVE

TITLE: CEM^R COAXIAL MAGNETRON

ENG.	MFG.	Q.C.	MARKETING
T. E. Ruden	Frank [illegible]		

	LOCATION	ECO NO.	DESCRIPTION	DATE	APPROVAL
A			Re-typed		

The provisions of the latest issue of MIL-E-1 apply to this specification

DESCRIPTION Tunable frequency, integral magnet, air cooled, 1000 kw min. power output, 3.5 to 3.7 GHz.

ABSOLUTE MAXIMUM AND MINIMUM RATINGS: Note 1

INDEPENDENT

PARAMETER	If Surge	tk	VSWR	Tuner Torque	Body Temp	Input Bushing Temp	Pressurization Input	Pressurization Output	epy	
UNITS	a	sec		in-oz	°C	°C	psia	psia	kv	
MAXIMUM	17	---	1.5/1	40	125	270	30	30	50	
MINIMUM	--	480	---	--	-50	---	13	15	--	
NOTES	25	16		2	3	3	4	--	--	

DEPENDENT

PARAMETER	Ef	if	ib	Pi	pi	Du	tpc	prr	rrv
UNITS	Vac	A	a	W	kw	—	µsec	pps	kV/µs
MAXIMUM	66	3.5	60	2640	2640	.001	2.0	1150	65
MINIMUM	---	---	20	---	---	---	0.75	----	55
NOTES	5, 16						6		7

MECHANICAL

MOUNTING POSITION ____ Any, See note 21

SUPPORT ____ Cradle Mount

COOLING ____ Forced air (See note 8)

OUTLINE ____ See Figure 1

MAGNET ____ See note 9

COUPLING ____ Mates with UG-585A/U Flange

NET WEIGHT ____ 65 pounds nominal

Cavity Pressure ____ 20 psig, SF_6, See note 15

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	MAX	UNITS
	General					
---	Marking	Figure 1	---	---	---	---
---	Holding Period		---	168	---	Hrs
---	Dimensions	Figure 1	---	---	---	---
4.2	Qualification					
1143	Air Cooling	Osc. (1); $T_A = 25^oC \pm 5^oC$ (Notes 8, 11, 12)	ΔT	---	85	C° Ris
---	Shock	G = 30; t = 11 ms ± 1 ms No Voltages (Notes 14 & 22)	---	---	---	---
4309	Phase of Sink	No Voltages, F = F3	---	0.3	0.5	D/λg obj.
---	High Frequency Vibration	No Voltages, F = 50 Hz (Notes 14 & 27)	---	---	---	---
---	Preparation for Delivery	Note 29	---	---	---	---
4.6	Life Test	Note 23	t ---	2000 494	--- ---	hrs cycles
	Quality Conformance Inspection, Part I	Notes 19, 30				
1301 --- ---	Heater Current	Ef = 66 VAC; tk = 480 Sec. Min.	If	2.00	3.50	A
---	Coupling	VSWR = 1.05 Max	---	---	---	---
4303	Heater-Cathode Warm-up time	Ef = 66VAC; tk = 480 Sec (Notes 5, 16)	---	---	---	---
4304	Pulse Characteristics	tpc = 0.9 ± 0.10 us; Du = 0.001 rrv = 55 kv/us min. Notes 6 & 7				
---	Average Anode Current	Ib = 55 mAdc	---	---	---	---

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	LIMITS MAX	UNITS
4306	Pulse Voltage	F = F1 - F3	epy	34	42	kv
4250	Power Output	F = F1 - F3 (Notes 18 & 28)	Po	1000	---	W
4308	Spectrum Measurements	F = F1, F3, (Note 17)				
	Radio Frequency Bandwidth		BW	---	2/tpc	MHz
	Spectrum Side Lobes		SL	9	---	dB
4315	Stability	F = F1 - F3 (Note 20)	MP	---	0.25	%
4223 4.8.14	Tunable Frequency	Upper Limit Lower Limit (Note 13)	F F	F3 ---	--- F1	MHz MHz
	Quality Conformance Inspection, Part II	Notes 10, 19, & 24				
4310	Pulling Factor	F = F1, F2, F3, Osc.(1) (Note 26)	ΔF	---	2.5	MHz
4311	Pushing Factor	F = F1, F2, F3; Osc.(1) ib = 50 - 60 A	ΔF/ΔA	---	30	KHz/A
---	Spectrum Measurements	Osc (1)				
	RF Bandwidth	-40 dB Level	ΔF	---	10/tpc	MHz
	Spurious Radiation	Outside 10/tpc	Level	-50	---	dB
4003	Pressurization	Cavity, SF_6 note 15	---	20	25	psig
---	Tuner Drive Torque	$25^{o}C \pm 5^{o}C$ No Voltages	Torque	---	40	in-oz.

MIL-E-1	TEST	CONDITIONS	SYMBOL	LIMITS MIN	LIMITS MAX	UNITS
	<u>Life Test End Points (From Qualification)</u>					
4250	Power Output	Osc. (1); F1 - F_3	Po	800	---	watts
4308	Radio Frequency Bandwidth	Osc. (1); F1 - F3 Note 17	BW	---	2.5/tpc	MHz
4308	Spectrum Side Lobes	Osc. (1); F1 - F_3 Note 17	SL	6	---	dB
4315	Stability	Osc. (1); F1 - F_3 Note 20	MP	---	0.5	%

NOTES:

1. The requirements of paragraph 6.5 of MIL-E-1 shall apply. For the assistance of designers of electronic equipment, the ratings have been divided into two groups as follows;

   a.) Independent (ratings which may be obtained simultaneously).

   b.) Dependent (ratings which are interrelated and may not necessarily be obtained sumultaneously).

2. The tuner drive shall be capable of supplying a minimum of 30 inch-ounces of torque to the magnetron tuning shaft and shall never supply more than 40 inch-ounces of torque (including inertial effects) under stable conditions.

3. The temperature is to be measured at the point indicated on Figure 1, TMAX under conditions of Osc (1); TMIN under conditions of No Oscillation, No Heater Power.

4. The magnetron shall be capable of normal operation without electrical breakdown with the input bushing at normal atmospheric conditions.

5. Prior to the application of high voltage, the cathode shall be heated to the required initial operating temperature. This shall be done by applying 66 volts $\pm$ 5 percent for 480 seconds minimum. On the application of anode voltage, the heater voltage must be reduced according to the following:

   $E_f = 40 \pm 5\%$ volts $\quad 750 \leq P_i \leq 1900$ W

   $E_f = 30 \pm 5\%$ volts $\quad 1900 < P_i \leq 2640$ W

   For prolonged standby

   $E_f = 66 \pm 5\%$ volts

6. The characteristics of the applied pulse must be those which result in proper starting and oscillation. The rate of rise of the voltage pulse, the percentage of pulse voltage ripple, and the rate of pulse voltage fall are among the more important considerations. The tube manufacturer should be consulted regarding pulse characteristics as related to the specific application.

7. The rate of rise of voltage (rrv) shall be measured in accordance with MIL-E-1 Method 4304 except that the steepest tangent to the leading edge of the voltage pulse shall be measured above the 70 percent amplitude point.

8. The cooling required is partially determined by the total power input to the magnetron. The following table gives MINIMUM air flow and back pressure values that are deemed necessary to limit the body temperature to a maximum of 125 °C at an ambient temperature of 40°C at sea level.

Total Magnetron Power Input (Watts)	Cooling Air Flow Cu. Ft./min.	Air Pressure at Entrance to Cooling System Inches of Water
Standby Condition	20	1.0
2640	100	2.5

NOTES:

9. In handling and mounting the magnetron, care must be exercised to prevent demagnetization. Maintain minimum clearance of 8 inches between magnet materials, steel tools, plates, etc. and 12 inches between other magnets.

10. The following code defines the test frequencies:

F1	F2	F3
F1 = 3500 MHz	F2 = 3600 MHz	F3 = 3700 MHz

11. Temperature measurements shall be made only after thermal equilibrium has been reached.

12. With the specified airflow, using a conduit which fits snugly to the cooling fins, the rise above ambient specified shall not be exceeded.

13. The tuning mechanism shall operate as specified over the entire frequency range. The number of turns of the tuner shaft required to tune from F1 to F3 shall be nominally 150.

14. Prior to, and after completion of this test, the tube shall meet the pulse voltage and power output tests of Osc. (1).

15. The specified pressure shall be applied to the cavity. Consult tube manufacturer for SF_6 gas specification and cavity purge procedure.

16. 480 seconds required for Ef of 66 V.

17. The radio frequency bandwidth and side lobes shall be within the limits specified when a VSWR of 1.5 minimum is introduced in the load at a distance of 0.2 $\pm$ 0.05 meters from the magnetron flange and the phase is adjusted at the start of each measurement to produce maximum degradation.

18. The minimum power output requirement must be satisfied over the specified frequency band. See note 10.

19. Unless otherwise specified, all tests required by this specification shall be made under the following atmospheric conditions:

Ambient Temperature, $T_A = 25 \pm 10^\circ C$
Relative Humidity = 90% or less
Barometric Pressure = Local Standard

20. Stability shall be measured in terms of the average number of output pulses missing, expressed as a percentage of the number of input pulses applied during the period of observation. The missing pulses (MP) due to any causes, are considered to be missing if the RF energy is less than 70 percent of the normal energy level. The stability shall be measured when a VSWR of 1.5 minimum is introduced in that phase producing maximum instability.

NOTES:

21. Tube manufacturer should be consulted on cradle mount design for specified orientation.

22. The tube shall be subjected to 9 impact shocks of 50 g, consisting of three shocks in opposite directions along each of three axes perpendicular to planes A, B, and C, Figure 1, with each shock impulse having a time duration of 11 ± 1 milliseconds. The "g" value shall be within ± 10 percent when measured with a .2 to 250 cps filter, and the maximum "g" shall occur at approximately 5-1/2 milliseconds.

23. The intermittent life test shall be conducted while the phase of a 1.5 minimum VSWR located at a distance of 0.2 ± 0.05 meters from the magnetron flange is uniformly and continuously cycled through 360 electrical degrees with a time interval of approximately 30 minutes per cycle. Simultaneously the magnetron frequency, starting at F1, increasing to F3, then decreasing to F1 shall be changed approximately 100 Megahertz approximately every 50 hours.

Condition	Ib (mAdc)	Ef (Vac)	Duration (minutes)
Standby	0	66	8
Osc. (1)	55	30	225
Off	0	0	10

This cycle to be repeated until the accumulated radiate time equals the specified life.

24. Rejection and resubmittals shall be in accordance with MIL-STD-105, Section 12. The AQL of the combined defectives for attributes in Quality Conformance Inspection, Part 1 excluding inoperatives, shall be 1 percent.

25. The internal impedance of the heater filament supply shall limit the surge current to the maximum specified.

26. The procedure in MIL-E-1 method 4310 shall be followed.

27. The tube shall be mounted in a rigid fixture and vibrated with simple harmonic motion at a double amplitude (total excursion) or .006 inch. The tube shall be vibrated in three axes for a period of one minute in each axis. The axes of vibration shall be perpendicular to planes A, B and C as shown on the outline drawing, Figure 1.

28. It shall be an objective of the initial procurement to specify a tube with the final ratio of the maximum power specification to the minimum power specification of 1.4. The final specification must fall within the stated limits given in this current specification.

NOTES:

29. Preparation for delivery

a.) Packaging and Packing. Electron tube shall be packaged in accordance with MIL-E-75 package, Group 9. Electron tubes shall be cushioned and positioned in a snug-fitting metal, plastic or other suitable container which will pass the tests of MIL-E-75.

b.) Marking. Containers shall be marked in accordance with MIL-E-75, or as specified in the contractor order.

30. The modulator shall be such that the energy per pulse delivered to the tube, if arcing occurs, shall not greatly exceed the normal energy per pulse. The tube heater shall be protected against arcing by use of a connector that places a minimum of .05 μf across the heater directly at the input terminals.

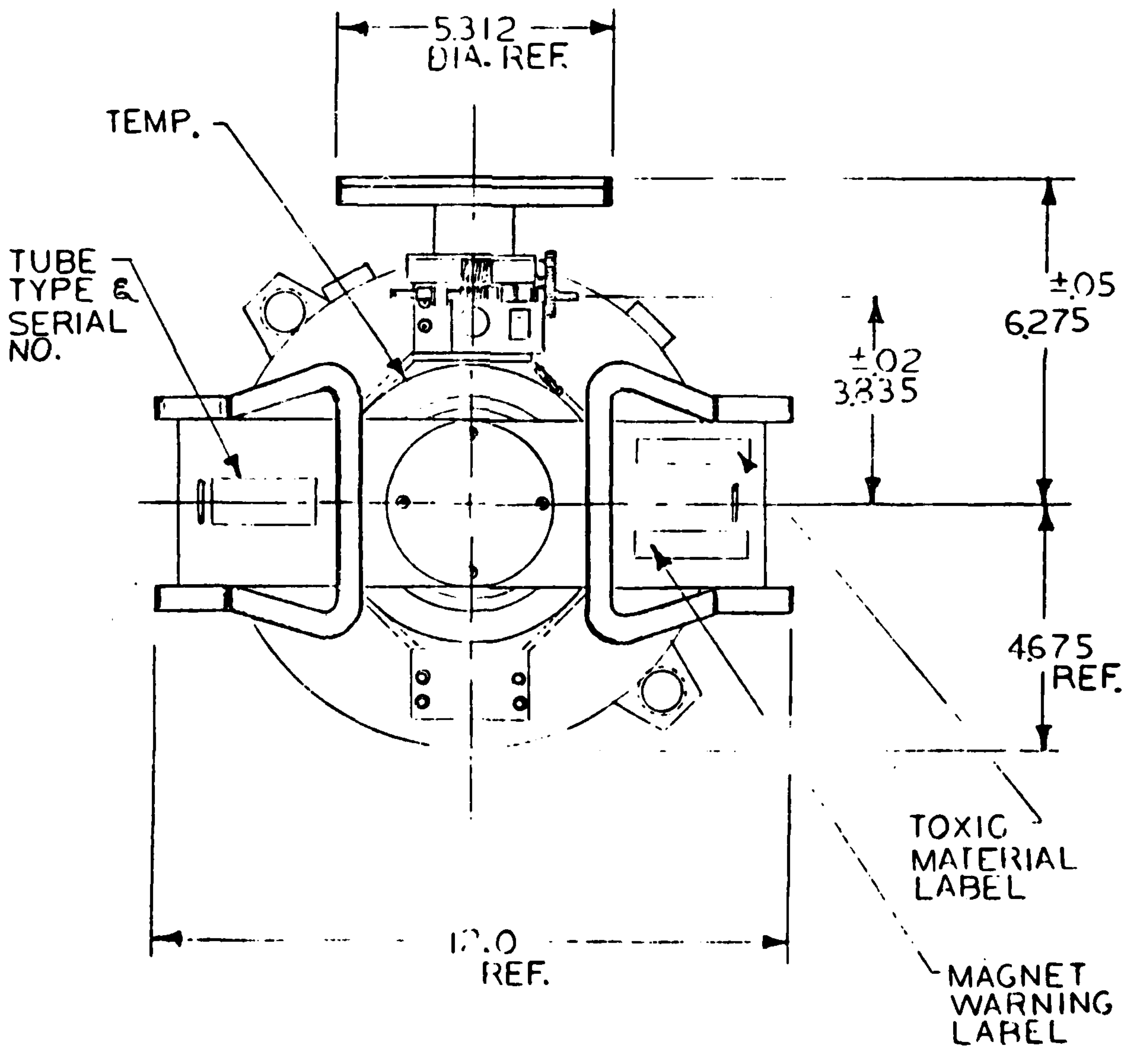

5.312
DIA. REF.
TEMP.
TUBE
TYPE &
SERIAL
NO.
±.05
6.275
±.02
3.835
4.675
REF.
TOXIC
MATERIAL
LABEL
REF.
MAGNET
WARNING
LABEL

FIGURE I

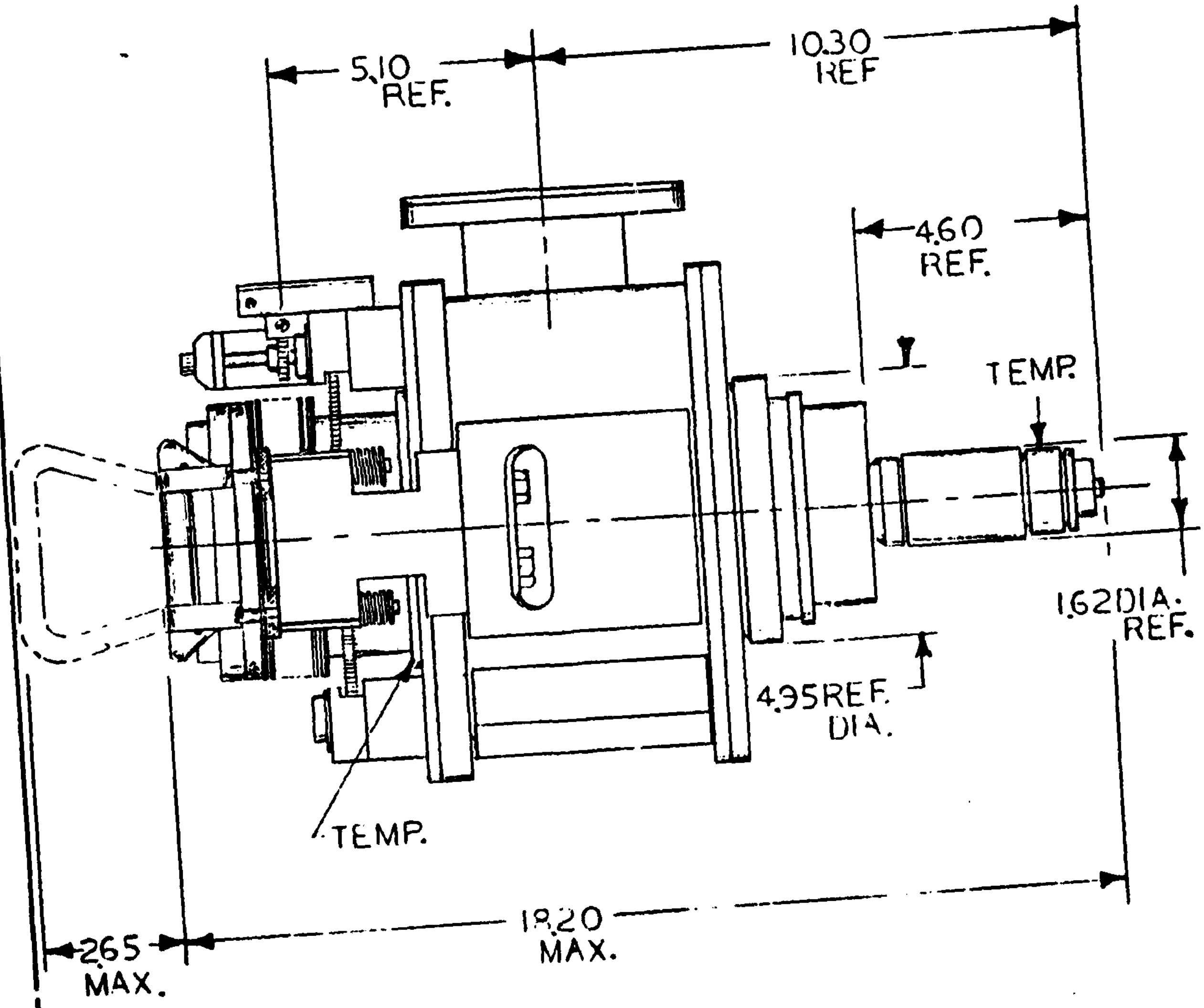

5.10
REF.
10.30
REF
4.60
REF.
TEMP.
1.620 DIA.
REF.
4.95 REF.
DIA.
TEMP.
18.20
MAX.
2.65
MAX.

FIGURE Ia

DATE
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